INSTITUTION

OF

MECHANICAL ENGINEERS.

PROCEEDINGS.

28072

1854.

PUBLISHED BY THE INSTITUTION,
81 NEWHALL STREET, BIRMINGHAM.

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BIRMINGHAM:
PRINTED AT M. BILLING'S STEAM-PRESS OFFICES, 74, 75, AND 76, NEWHALL-STREET.

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PROCEEDINGS.

January 25, 1854.

The Seventh Annual General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, 25th January, 1854; Archibald Slate, Esq., Vice-President, in the Chair, succeeded by William Fairbairn, Esq., President.

The Minutes of the last General Meeting were read by the Secretary, and were confirmed.

The Secretary then read the following

ANNUAL REPORT OF THE COUNCIL, 1854.

The Council have much pleasure in congratulating the Members, on this occasion of the Seventh Anniversary of the Institution, upon its satisfactory position, the increase in the number of Members, and the successful progress and advancement of the Institution.

The number of Members, &c., for the last year is 216, of whom 13 are Honorary Members, and 3 are Graduates.

The Financial statement of the affairs of the Institution for the year ending 31st December, 1853, shows a balance in the Treasurer's hands of £194 12*s.* 9*d.*, after the payment of all accounts due to that date. The Finance Committee have examined and checked all the receipts and payments of the Institution for the last year, 1853, and have reported that the following balance sheet rendered by the Treasurer is correct.

(*See Balance Sheet appended.*)

The Council have the pleasure of announcing that the following donations to the library of the Institution have been received during the past year:—

Courses of Engineering Lectures at the "Ecole Impériale des Ponts et Chaussées," at Paris, presented by M. Cavalier, Director :—
Mechanics, by M. Belanger.
Hydraulics, by M. Belanger.
Inland Navigation, by M. Mary.
Sea Ports, by M. Frissard.
Construction of Roads.
Instruments for Surveying and Levelling.
Mineralogy and Geology, applied to building, by M. Dufrénoy.
Characteristic Fossils of different formations, by M. Dufrénoy.

D. K. Clark on Railway Machinery, from the Author.

T. S. Prideaux on the Economy of Fuel in Reverberatory Furnaces, &c., from the Author.

R. Roberts on Improvements in Vessels, &c., from the Author.

T. Webster on Property in Designs and Inventions, from the Author.

J. Weale, Illustrated Catalogue of Works on Architecture and Engineering.

Journal of the Society of Arts.

Minutes of Proceedings of the Institution of Civil Engineers.

Transactions of the Liverpool Polytechnic Society.

The Artizan Journal, from the Editor.

The Civil Engineer and Architect's Journal, from the Editor.

The London Journal of Arts, from the Editor.

The Mechanic's Magazine, from the Editor.

The Mining Journal, from the Editor.

The Practical Mechanic's Journal, from the Editor.

Engravings of Equilibrium Canal Lift, by Mr. Archibald Slate.

Medal of Mr. Robert Stephenson, presented by Mr. Edwin Clark.

The Council have great pleasure in referring to the increased number, and practical importance, of the papers that have been presented to the Institution during the past year, and express their thanks to the Authors of the papers for the valuable information they have furnished to the Institution. The Council confidently anticipate a continued advancement in the importance and number of the communications brought before the Institution, and they trust that all the Members will aid, as far as they have opportunity, in advancing the objects of the

Institution by contributing papers on engineering subjects that have come under their observation, and communicating the particulars of executed works, with the results of their practical working, whether successful or unfavourable, that may be serviceable and interesting to the Members. The Council invite communications from the Members and their friends, upon the subjects in the list appended, and other subjects advantageous to the Institution; also contributions to the collection of mechanical models and drawings, and books for the library, with statistical returns and indicator-cards of the working of engines, to promote the objects of the Institution.

The following papers have been read at the meetings during the last year:—

On an Improved Railway Chair; by Mr. John McConochie, of Wednesbury.

On Iron, and some improvements in its manufacture; by Mr. J. D. Morries Stirling, of Birmingham.

A description of Cugnot's original invention of the Locomotive Steam Engine for common roads; by Mr. Edward A. Cowper, of London.

A description of an Oil Axle Box for Engines and Tenders; by Mr. Alexander Allan, of Crewe.

On Improved India Rubber Springs for Railway Engines, Carriages, &c.; by Mr. William G. Craig, of Newport.

On Railway Axle Lubrication; by Mr. W. B. Adams, of London.

On a new Lubricating Material; by Mr. John Lea, of London.

On Messrs. Cox and Wilson's Portable Single-acting Steam Engine; by Mr. T. T. Chellingworth, of Birmingham.

On the Mathematical Principles of the Centrifugal Pump (second paper); by Mr. Andrew J. Robertson, of London.

On an improved Governor for Steam Engines; by Mr. C. William Siemens, of London.

On Hollow Railway Axles; by Mr. J. E. McConnell, of Wolverton.

On an improved Railway Joint Chair; by Mr. R. S. Norris, of Warrington.

A Description of the new Pumping Engines at the Birmingham Water Works; by Mr. W. S. Garland, of Soho, Birmingham.

On an Escape Water Valve and a Governor for Marine Steam Engines; by Mr. R. Waddell, of Liverpool.

Description of an improved Coking Crane, for supplying Locomotive Engines; by Mr. J. Ramsbottom, of Manchester.

On an improved Turn Table; by Mr. Samuel Lloyd, jun., of Wednesbury.

On an improved Apparatus for preventing Explosions of Steam Boilers; by Mr. J. Rolinson, of Brierley Hill.

A Description of the new Winding Engine at Dukinfield Colliery; by Mr. William Fairbairn, of Manchester.

On the Combing of Fibrous Materials; by Mr. Benjamin Fothergill, of Manchester.

On the American Dry Clay Brick-making Machine; by Mr. Edward Jones, of Liverpool.

On an improved Water Meter; by Mr. B. Fothergill, of Manchester.

On the Retardation and Stoppage of Railway Trains; by Mr. W. Fairbairn, of Manchester.

It is with particular pleasure that the Council have to mention the meeting of the Institution held in Manchester in December last, and the valuable papers that were read there; and they have the gratification of acknowledging the kindness and liberality with which the Council of the Royal Institution granted the free use of their lecture theatre for the meeting.

The officers of the Institution, and five of the members of the Council in rotation, will go out of office this day, according to the rules of the Institution; and the ballot will be taken at the present Annual Meeting for the election of the Officers and Council for the ensuing year.

The CHAIRMAN remarked that the report of the Institution presented was very satisfactory and prosperous, both financially and generally; and it was a great satisfaction to observe the continued advance in the value and number of the communications brought before the Institution; these had included improvements in most branches of mechanical engineering, and he was confident the Institution would continue advancing in importance and utility by the active co-operation

and interest of the members. A good sign of their heartiness in the cause, and that those on the list of members were active supporters, was the very small amount of arrears of subscriptions; this was a point of great practical importance in the success of an Institution, and he believed their position was unusually favourable in that respect.

The CHAIRMAN moved that the report be received and adopted, which was passed.

The CHAIRMAN announced that the Ballot-papers had been opened by the Committee appointed for the purpose, and the following Officers and Members of Council were duly elected for the ensuing year:—

PRESIDENT.

WILLIAM FAIRBAIRN, Manchester.

VICE-PRESIDENTS.

SAMUEL H. BLACKWELL, Dudley.
EDWARD JONES, Liverpool.
JOHN PENN, London.
JOHN RAMSBOTTOM, Manchester.
ARCHIBALD SLATE, Dudley.
JOSEPH WHITWORTH, Manchester.

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JAMES FENTON, Bradford.
JAMES E. MCCONNELL, Wolverton.
WILLIAM MATHEWS, Birmingham.

TREASURER.

CHARLES GEACH, M.P., Birmingham.

SECRETARY.

WILLIAM P. MARSHALL, Birmingham.

The following New Members were also elected:—

MEMBERS.

DANIEL K. CLARK, Aberdeen.
JOHN E. HODGKIN, Birmingham.
GEORGE B. LLOYD, Birmingham.
RICHARD PILKINGTON, JUN., St. Helens.

HONORARY MEMBER.

JOSEPH WOOLLEY, LL.D., Portsmouth.

William Fairbairn, Esq., President, was then called to the Chair, and said that he felt highly honoured in being elected as President of the Institution of Mechanical Engineers, and that more particularly as the successor of the two distinguished men who had been the previous Presidents of the Institution. He felt a great interest in the Institution, and would do his utmost to promote its success. He considered the objects of the Institution to be very important in character, and it was certain a progressive advance in value and efficiency would be the result if the Members exerted themselves in supporting it, and supplying original papers descriptive of works executed, or new improvements and inventions. He should have great pleasure in assisting by all the means in his power in advancing the interests of the Institution; and he trusted that the ensuing year would prove not only useful and instructive to the members, but productive of benefit to the public as well as the profession.

The following Paper, by Mr. Charles William Siemens, of London, was then read:—

ON AN IMPROVED WATER METER.

The rapid growth of Water Works in this and other civilised countries, extending to towns of second and third rate importance, has rendered the production of an efficient Water Meter a matter of considerable practical interest. The water acquires in its transmission from the source to its destination a certain value payable by the consumer. If the consumer is a private householder, it is possible to estimate his probable consumption, supposing that no water is wasted by allowing taps to leak or to be left opened, but calculation entirely fails to estimate the quantity of water consumed in manufactories, baths and wash-houses, &c. The consequence is, the larger proportion of the water supplied to a town is absolutely lost, and falls to the equal charge of the thrifty and wasteful.

A good Water Meter will not be limited in its application to the purpose of Water Works; it will be found a useful auxiliary to brewers, distillers, and liquid merchants generally; moreover to engineers, and indeed to all engine proprietors, it will be of essen-

tial service, by furnishing a register of the water pumped into steam boilers; from which a correct estimate may be found of the evaporative powers of the boiler, and the relative quantity of the fuel employed, independently of the working conditions of the engine.

The Meter is required to fulfil the following conditions :—

1. It must register correctly upon a counter the quantity of water passed through the meter, either at high or low speeds.
2. It must not be affected by the pressure of a high column of water upon its working parts.
3. It must allow the water to pass through without obstructing or at intervals checking the same.
4. Its working parts must be protected against the effects of mechanical impurities or corrosive agencies in the water, so as to insure its continuous working without frequent attention.
5. It must be a cheap and compact instrument, adapting itself conveniently and locally to ordinary circumstances.
6. Its working and registering parts must be inaccessible to the employer, in order to prevent fraud.

The fulfilment of these conditions might at first sight appear but an easy problem for a skilled mechanician, but the numerous and fruitless attempts that have been made at its solution have proved the real difficulty of the task. In order to combat these difficulties successfully, it is necessary to discriminate between those that are inseparably connected with certain principles of action, and those of mere detail of arrangement, or choice of material. All meters that have hitherto been proposed may be classed under the four following heads, viz. : —

1. Cistern or Bucket Meters.
2. Piston Meters.
3. Meters by Area of Channel.
4. Meters by Impact.

The intermittent supply system which prevails in London and elsewhere, is indeed a supply by Cistern or Bucket Meter, in its most primitive form. Each house or factory is provided with a cistern capable of holding the necessary supply for a day, or other

convenient period of time. The turncock in making his regular rounds fills the cisterns, which are provided each with a separate ball-cock, to prevent their overflowing.

This mode of supply has been found quite inadequate for large and irregular consumers, but even for private houses it entails so much inconvenience and expense (principally to the consumers) that the legislature has thought fit to interfere, and now insists on a continuous supply. With the continuous supply, the liability to the water being wasted is very much increased, unless a self-registering method is applied.

Mr. Mead, of London, proposed a registering Bucket Meter, of very simple construction, which is represented in Fig. 1, Plate 1. It consisted of a mould or double bucket A, that is divided equally by a division B, and is at liberty to rock upon a centre C. Perpendicularly above this rocking centre is the open mouth of the supply pipe D, filling alternately the one and the other bucket. At the extremities of the buckets, small pockets E E are provided, that fill at the instant the mould overflows, and being at the greatest distance from the rocking centre, cause the filled bucket to overbalance the empty one, and to discharge itself into the cistern F below. The supply of water is regulated by means of a float G, and a cock H, as will be readily understood. The rocking shaft C gives motion to a counter that is not shown, by means of a ratchet and wheel.

Mr. Parkinson, of London, has invented a Bucket Meter, pertaining in its construction to the ordinary gas meter, which is found to register the water passing through with great accuracy, and is actually used to a great extent in connection with receiving cisterns.

It would be interesting to add to the list of bucket meters, contrivances both cheap in construction and capable of measuring liquids with accuracy, were it not that these meters destroy the onward pressure of the water, and are of necessity incumbered by cisterns at elevations above the premises supplied, which cisterns entail great expense and inconvenience.

The name "Piston Meter" is intended to comprise all meters in which the fluid is measured by displacing a piston, a disc, or a diaphragm, and thereby filling a measured cavity.

The "piston meter" in this respect resembles the "bucket meter," with the advantage of transmitting the onward pressure of the water, and of dispensing with the necessity of a cistern. On the other hand it labours under great and peculiar disadvantages, partly on account of the valves and pistons which are employed being quickly destroyed by the sand and other impurities contained in the water, or broken by its impact against them, and partly on account of their great bulk and expense in proportion to the water measured.

It will only be necessary to mention a few of the multitude of piston meters that have been proposed, for the sake of illustration. Those of Lewis and Taylor, both of Manchester, and of Messrs. Barr and Macnal, of Paisley, are examples of single cylinder meters, with tumbler arrangements to reverse the valves suddenly, in order not to check sensibly the column of water moving through the pipes. Captain Ericsson, of America, and Mr. Chrimes, of Rotherham, simultaneously proposed a meter consisting of two cylinders working on cranks at right angles to one another, in order to equalise the flow through the pipes, and to be able to apply side valves, worked by eccentrics, in place of the more complicated tumbler arrangements. Mr. Roberts, of Manchester, constructed, in 1851, a cylinder meter, made to tumble or oscillate by the weight of the piston. Messrs. Bryan, Donkin, and Co., of London, invented, in 1850, a disc meter; Mr. Parkenson, of Bury, and Messrs. Chadwick and Hanson, of Salford, have substituted india-rubber diaphragms for the piston and the disc respectively. Mr. Adamson, of Leeds, made a meter resembling the rotary engine, in which direction he has been followed by several others.

The last-named meter is the only one of this class that has been practically used for several years (at Leeds), but was finally superseded, on account of excessive wear and tear, and frequent stoppages.

A meter "by area of flow" pre-supposes a constancy of pressure, and knowledge of the time of continuation of flow. It is practically resorted to for measuring approximately large volumes of water, by passing it over an overflow, and taking into account the depth of water column, its breadth, and the time of flowing.

In Paris, Genoa, and other cities on the continent, the water has for many years been supplied to each individual consumer,

through very contracted jets at the extremities of the pipes, through which the water continually issues with supposed uniformity of speed into receiving cisterns. It is evident that this mode of supply is fraught with all the inconvenience of the intermittent system, without possessing the advantage of relieving occasionally the supply pipes from pressure, for the purpose of repairs, &c.

The great inconvenience of this system is illustrated by the fact, that many houses in Paris require upwards of ten cisterns for the supply of the different inmates. It is unjust, for it obliges every consumer to pay at a maximum rate.

Several years since (in 1845), the writer of the present paper imagined a meter by area of channel, which dispensed with the necessity of a cistern, and registered the quantity of water actually passed through. It is shown in Fig. 2, Plate 1, and consisted of a piece of square pipe A, containing a common flap-valve B, which the water has to raise in order to pass through. The spindle of this valve passes through a stuffing-box, and carries the lever C, which by its motion raises or lowers a driving strap D, upon the reversed cones E F. The cone E receives a regular motion by means of a clockwork G, while the cone F communicates the motion received through the strap to a counter at H, with a dial plate I; if no water passes through, the valve B rests at the bottom, and the clockwork is entirely stopped by means of a detent K; the instant the valve B is raised by the passage of water, the clockwork is released, and imparts a very slow motion to the counter; but in proportion as the flow increases, the strap rises, and the motion of the counter is increased. A correct registration is thus obtained, provided the elevation of the flap-valve is proportionate to the amount of water passing through, which is practically the case, since the constant weight of the valve itself renders the velocity of flow under its edge constant.

A meter differing only in the details from the above has recently been brought out by Mr. Kennedy, of Kilmarnock.

The frequent necessity for winding up the clock movement rendered this meter evidently unfit for general application. To obviate this, the writer thought of abstracting the motive power for

the clock from the water itself, by introducing a screw propeller into the pipe.

Being advanced thus far, it became apparent that the valve and clockwork might be entirely dispensed with, if the propeller could be made to rotate in the precise ratio of the moving column of water, and to impart that motion directly to the counter.

Thus the first step was made toward the production of a "Meter by Impact," by which it is contended the conditions above enumerated of a perfect meter are most fully realized.

The writer considers it an essential condition of a "Meter by Impact," that the propelled vanes merely glide edgeways through the water, by partaking fully of its onward motion, without sensibly impeding or agitating the same.

These conditions are most fully complied with, by a perfect screw suspended on two pivots, in the axis of the moving column of water. They are also fulfilled by a Barker's-mill, or turbine of spiral blades, that yield to the motion of the water outward from a centre.

If, on the other hand, the vanes of the propeller are of irregular shape, so as to form eddies or obstructions in the water, it will be theoretically impossible to insure a uniform increasing rate of rotation with increased velocity of current; for the retarding or accelerating effects produced by eddies or concussions increase not in the simple, but in the square ratio with the velocity.

The correctness of this argument was proved indirectly, and unknown to the writer, by the failure of an attempt made at about the period referred to, by Mr. Abraham, to register the water flowing through a pipe by means of a screw propeller of irregular form, although suspended with great care between points of agate.

The same unsatisfactory result was obtained some years later by Mr. Tebay, of London, who formed his propeller by making radial incisions into a disc of brass plate, mounted upon a spindle, and by twisting each segment in the same manner, like the vanes of a windmill. He endeavoured to counteract the inaccuracy of his propeller, by introducing valves so contrived that the water should be able to pass only at a fixed velocity.

In order to obtain correct measurement by an "impact meter,"

it is not sufficient that the propeller should yield equally in all its parts to the motion of the water, but it must also possess the power to overcome a uniform resistance by friction in its bearings, &c., without diminishing its proportionate rate of rotation at low speeds.

The apprehension of these difficulties deterred the writer, for several years, from proceeding, until the pressing want for a meter to carry out some other improvements induced him to construct, in 1850, the identical meter now before the meeting; and which, in point of accuracy of measurement and compactness, fully satisfied a committee of inquiry of the Manchester Corporation Water Works, by whom its adoption was recommended. The successful results obtained by this meter, which the writer had not even an opportunity to adjust previous to its official trial, were thought strong proofs in favour of the principle involved. He was indebted for the admirable first execution of his idea, and some valuable suggestions, to his brothers at Berlin.

In attempting, however, to put the meter into regular service, under a working pressure of upwards of 200 feet column of water, subject to violent concussions, and acted upon by mechanical as well as chemical impurities in the water, he, and the spirited manufacturers, Messrs. Guest and Chrimes, of Rotherham, had had to encounter many serious difficulties, which had to be dealt with one after another, but which finally determined them to adopt for smaller meters the more simple arrangement of a spiral curve, or Barker's-mill.

The two arrangements now actually adopted are shown in Plates 2, 3, and 4. Plate 2 shows a double screw, or balance meter, capable of measuring 100,000 gallons per hour, or above two million gallons per day.

Fig. 3 is a sectional elevation of the meter; and Fig. 4, Plate 3, is a transverse section through one of the screw propellers.

This meter consists of a cylindrical casing A, which is lined throughout with a brass tube drawn to a precise gauge, and is connected by its flanges B B to a line of piping of 8 or 9 inches in diameter.

The measuring apparatus contained in this casing consists of

two hollow drums EE, carrying on their circumference, the one a set of right-handed, and the other a set of left-handed screw blades; of the conical blocks HH, armed with radial projections or guide-blades KK; a central bracket L, containing support for the bevil wheels NN, on upright spindles, and the wheels MM, on the horizontal spindles of the screw drums; also two double inverted cones at contractions RR, and a grating B, at one end only.

The spindle of the wheel N passes upward through the hollow arm of the central bracket L, into a close chamber F, carrying an endless screw U, which is geared to a pair of reducing wheels VV.

The spindle of the latter wheel is ground air-tight into a socket of the strong metallic plate T, and passes into the upper chamber G, carrying a pinion X, which is geared into two wheels Y and Z, of equal diameters, but the former with 101, and the latter with 100 teeth. The wheel of 101 teeth carries a large dial plate O, divided in its circumference into 100 equal divisions; and the wheel of 100 teeth is fixed upon the upright spindle, and carries a hand Q, upon the dial. The dial in travelling through the breadth of one division under a fixed pointer is intended to indicate the passage of 100 gallons through the meter. For every one complete revolution of the dial, the hand advances relatively through the breadth of one division, signifying the passage of 100,000 gallons. The millions of gallons are indicated on a separate circle of divisions on the large dial, by a hand R, which receives a reduced motion by a wheel S, of 100 teeth, rotating bodily with the dial, gearing into a pinion of 10 teeth, fixed to the upright spindle.

The dial face is exposed to view through the cover of plate glass I.

The water enters the meter through the grating P, which is provided to arrest large solid bodies that might obstruct the working of the meter. The inverted cone R directs the current of water toward the centre, where it again spreads over the conical block H, and being directed parallel to the axis between the guide vanes K, it impinges obliquely upon the right-handed vanes of the hollow screw-drum E. The object of (figuratively speaking) kneading the current of water between the conical surfaces, is, to destroy partial

currents within the same, and in spreading it from the axis to increase its leverage on the rotating drum; the diameter of the body of the drum is made slightly smaller than the diameter of the conical block, in order to prevent the former from endway pressure of the moving column of water. Some clearance is allowed between the helical vanes and the surrounding casing, but the passage of water outside the vanes is effectually prevented by slight contractions of the water way at both ends. In order to prevent wear and friction on the bearings, the body of the revolving drum is made hollow to such an extent that the water displaced nearly balances the weight of metal. A screw drum of this description moves with a very gentle current of water, but it would, nevertheless, make a very imperfect meter if it were simply connected to the counter, inasmuch as the friction in the bearings and of the counter would retard it most at low speeds, and the friction of the vanes in gliding through the water (which increases in the ratio of the square of the velocity) would again greatly retard it at high speeds, the maximum rate of measurement being obtained at a medium speed.

By the addition of the second, or left-handed drum, these variations in speed are, however, very perfectly compensated. For the sake of illustration, let it be imagined that both screw drums revolve independently of each other (of course in opposite directions), and that the second or left-handed one alone imparts its motion to the dial; let it also be supposed that the friction of both drums is the same; the water, in meeting the oblique vanes of the first drum in a direction parallel to the axis, will be deflected from its straight course proportionally to the resistance to rotation of the drum, say an angle of 1°, as shown at A in Fig. 5, Plate 3. Pursuing its fresh course, it will strike the left-handed screw blades of the registering drum at B, in an angle at 1° more obtuse than the previous, and being deflected by the resistance offered through 1° in the opposite direction, it follows that the water passes out in a direction parallel to the axis, as at C, and, consequently, that a true rate of measurement is obtained. The condition of both drums being perfectly alike, it follows that the same compensation must be effected at all speeds. Nor is this compensating effect disturbed by coupling both drums rigidly together by bevil gearing, whereby a great practical

advantage is obtained, that, namely, of one drum assisting powerfully to overcome an obstruction offered to the other. Let it be imagined, for instance, that a pebble or piece of vegetable matter has wedged itself between the casing and tip of the vane of the first drum, so as to stop it entirely, and to force the column of water passing through into the helical course; the water would then impinge upon the left-handed vanes of the second drum rectangularly (supposing the inclination of the reverse vanes to be at an angle of 45° to the axis), and expend its entire momentum upon it, the effect of which would be added to the impact on the first drum through the bevil gearing, to overcome the obstruction. The motion is conveyed to the counter by the upper bevil wheel N, but the opposite wheel N is added to strengthen the connection between the two drums, and to relieve all the spindles from pressure. Before leaving the meter, the current of water is again contracted between conical surfaces, for the same purpose as before, namely, to equalize its flow.

In calculating the quantity of water that will effect one complete revolution of the screw-drums, it is necessary to compute the clear net area between them and the external casing, supposing all the surfaces to be covered with a film of stationary water (by adhesion), $\frac{1}{140}$th part of an inch in thickness, and to multiply the same by the pitch of the screw. The correction for adhesion amounts to an inappreciable quantity for large meters, but constitutes a considerable per-centage in the calculation for small meters, being equally exact for both.

The difficulties that have been encountered in the manufacture of this meter apply principally to the spindles; although relieved from all constant pressure, they have nevertheless to maintain the drums in their central position, and to resist a strain endways, caused by the mere friction of the water in passing along the vanes. They have in consequence to be made of hard metal; German-silver was chosen in the first instance, but could not be depended upon for strength. Steel is the best for hardness, but is soon corroded by the water, notwithstanding all attempts to protect it by zinc, or by a casing of brass, through which only the rounded point projected to receive the end strain at the bottom of the bearing. Agate points or plates are rapidly ground away when used in water. A hard bronze was found to be

the most suitable metal, and indeed answers well for meters of large size, but it is difficult to produce the spindles for small meters of that metal.

The difficulty at first experienced of producing screw-drums of correct shape and uniform size, without incurring a large amount of workmanship, was successfully removed by casting them, and many other parts, in metallic moulds. Gutta-percha was also tried by the manufacturers, which, being slightly lighter than water, was with its spindle exactly equal to the weight of water which it displaced; but it could not be made sufficiently correct and rigid in the vanes. After some time the manufacturers succeeded in casting drums for the larger meters of bronze, and in dry sand, with great accuracy. There was considerable difficulty at first in finding workmen who would fit the essential parts with the great accuracy they required, without refining on other parts that have only to be strong, to resist the rough usage to which the meters are subjected when taken in use.

The calcareous matter in water deposits only on the surfaces of brass that are not exposed to the current. It exercises therefore no effect on the measuring surface, but if allowed to penetrate into the chamber of the counter it incrusts the small wheels and spindles, and causes them to break or wear rapidly. To alleviate this, the first chamber F is separated completely from the interior of the meter, excepting the capillary space between the upright spindle and its bearing, through which the pressure in the pipes is transferred to the chamber, but which is too narrow to allow of an intermixture of fluids. This chamber is filled, before it leaves the manufactory, with pure olive oil, which affords a complete and continuous protection to the reducing wheels. The upper chamber of the counter is not under the pressure of the water, and contains atmospheric air. The differential motion between the wheels Y and Z, of 101 and 100 teeth respectively, produces a reduction of 100 to 1, or 100,000 to 1,000, indicated upon a single circle of divisions, whereby the use of the meter is much facilitated.

For meters of less than two-inch diameter of supply pipe, the spiral form of propeller, or Barker's-mill arrangement, is adapted, except in cases where the water acts impulsively, as for instance, in supplying steam boilers by means of pumps, where the double screw meter is the

only one applicable. Fig. 7, Plate 4, is a sectional representation of a spiral meter, intended for a half-inch supply pipe.

The water enters the meter through the pipe N, and traversing a cylindrical grating H, covered with wire gauze, it passes downward through the funnel K, into the propeller E, and issuing from two apertures of its circumference it passes into the chamber P, and thence into the exit pipe G.

The propeller is formed of two discs of metal, which are bulged upward, the upper one to form a funnel, fitting loosely over the inlet K, and the lower one to join to an upright spindle I. The two discs are joined by two spiral blades, as shown in plan in Fig. 6, Plate 3. At the bottom of the propeller a chamber C is formed, that is filled with oil through apertures O and Q, and sealed close, leaving only an eye in the centre, through which an upright stud of bronze B enters, which with its steel point abuts against a steel plate in the bottom of the propeller. The lower chamber F of the counter is formed of a white-metal casting, cast in one piece with the grating H, and filled completely with oil. The arrangement of the counter itself is precisely similar to that before described.

Theoretically speaking, this meter is less perfect than the compensating Screw Meter, but it possesses the great advantage of containing only a single bearing, at C, that is at all liable to wear, and that bearing is effectually protected from the action of the water. The practical effect of this simplification of parts has been, that of 150 meters of this description that are at work, not one has as yet been returned disabled or inaccurate.

Mr. Adamson, of Leeds, has lately projected a meter with two sets of spiral blades, upon the principle of a turbine, the inner set being stationary, and the outer set revolving; this meter also gives a very good result.

Another kind of meter lately brought out by Mr. Taylor, of Manchester, having a revolving horizontal drum or water-wheel, acts partially by jet and partially by impact, but on this account it appears to the writer imperfect in principle.

It has been argued before, that no accurate measurement can be effected by the application of jets. To avoid them in the spiral meter,

it is essential to make the area of the outlet larger than the area of the supply pipe. Nevertheless the nature of a jet still manifests itself to some extent by increasing the rate of the meter at high velocities. This defect has however been effectually counteracted by the application of rotating flies or drag boards LL, which offer a resistance increasing as the square of the velocity, and can be regulated to equal the effect obtained by the jet. They offer also great facility in adjusting the absolute measurement of the meter.

In order to insure the efficiency of each meter, it is necessary to test the same under variable pressures, and with considerable volumes of water. To this point the manufacturers, Messrs. Guest and Chrimes, have devoted great attention. The apparatus they employ consists of a large cistern, 40 feet high, and a second cistern below, capable of containing 1000 gallons, and accurately graduated throughout. A set of pipes is provided that have been proved to transmit given quantities of water per minute, under the pressure from the upper cistern. From 8 to 12 meters to be tested are coupled in a line, one behind another, to a pipe leading from the upper cistern to the outlet of the meters; the test pipes are then alternately connected, a uniform quantity of water, as shown in the cistern, is passed through each pipe, and the numbers of gallons indicated on the different counters are noted in a book opposite to the permanent numbers of the respective meters. An extract from this book shows how nearly correct a measurement is obtained.

Mr. Siemens exhibited specimens of his meters of the two kinds of construction described in the paper, with specimens of the castings for the spiral drums, &c.; also the first meter he had constructed on that principle.

He remarked that the mode adopted of insulating all the wheelwork in oil, was a point of great importance practically in water-meters, as wheels working in water were subjected to a deposit taking place upon them, increasing their friction and causing them to wear out; and it was an essential qualification for a good meter, that it should continue in constant action for a very long period without perceptible wear or inaccuracy. The upper chamber filled with oil was found to answer the purpose quite satisfactorily; the oil being lighter kept always in its

place, and could not be displaced by the water; the spindle passing from the oil chamber was ground in with a slightly conical shoulder.

The Chairman observed that there was great ingenuity shown both in the principle and the construction of the meter. He inquired how many of the meters there were at work?

Mr. Siemens replied that there were 200 or 300 of the screw meters at work, of very different sizes and pressures, and about 200 of the small meters on the Barker's-mill principle.

Mr. Clift observed that the object of the meter was to measure the water and deliver it at the same pressure at which it stood in the main, instead of cutting off the pressure entirely as Parkinson's meter did, and there would unquestionably be a great advantage in being able to deliver the water at high pressure, as in the case of measuring water into steam-engine boilers; but he thought there would be a corresponding disadvantage in the meter having always to bear this high pressure, and being subjected consequently to greater wear and tear in the working parts. In the case of Birmingham, the greater portion of the town was supplied at a pressure of 250 feet head of water, and great strength would therefore be required in every part of the meter to withstand this pressure, which would not be the case with Parkinson's. With regard to the spiral drums, however accurately they might be constructed, he thought they would be liable to considerable error in registering the quantity of water passed through, owing to the great variation of pressure under which they would have to work.

Mr. Cowper thought there was some misapprehension of the action of the meter under pressure; the velocity of the current of water passing through the meter would be exactly in proportion to the quantity of water discharged, whether under high or low pressure, and as the meter simply registered the velocity of the current through the fixed area of the meter, it would register with equal accuracy under any pressure. The whole of the meter was in equilibrium, having the same pressure on both sides of the spiral drums, and consequently there would be no strain upon the gearing from the pressure; the only strength required would be in the casing of the meter, which would have to be the same strength as the water pipes; but thin brass would serve for the moving parts of the meter, being in equilibrium of pressure, and under no more strain than the drum of an ordinary gas meter.

Mr. Clift thought that a strain might be thrown on the works of the meter by opening the pipe suddenly under heavy pressure, partially relieving the pressure from one side of the meter.

Mr. Siemens observed that the body of the meter was made larger in the area of passage than the outlet, and therefore the velocity of the current was slower through the spiral vanes of the meter than anywhere else; and there would be no practical difference of pressure between the two ends of the meter, because there was a free communication always open through the meter of larger area than the orifice of the pipe through which the water was flowing away.

Mr. Hodge did not see there could be any strain on the working parts of the meter, being all immersed in the water with an equalised pressure throughout, whether under high pressure, or only the pressure of the atmosphere.

Mr. Siemens said that the practical uniformity of measure was shown by the table of trials of the meters, the limit of error allowed being about 2 per cent.; they were made to register a little too much at the lowest speed, which was effected by increasing the drag-vanes beyond what was strictly necessary to counteract the tendency of the orifices in the propeller to form jets; it being manifest that the resistance of the drag-vanes, like the force of the jets, would increase as the square of the velocity.

The Chairman inquired whether the meters had been employed in regular use for both high and low pressures, and whether they were found to register correctly in both cases?

Mr. Siemens replied that many of them were at work under both circumstances, and no difference had been found in their measuring from being worked under different pressures from 300 feet to 1 foot head of water.

Mr. Clift inquired whether any difficulty had been experienced from the small particles and small shells contained in the water? He thought the fine fittings of the meter would be liable to be stopped by their accumulation. The expense of the meters, he feared, would be too great for very general use, on account of the superior workmanship required; and inquired the cost of the different sizes?

Mr. Siemens replied that there was always a grating fixed which prevented the entrance of anything into the meter that would be liable

to interfere with its action; and the smaller size of meters had a tubular grating (a specimen of which was shown), giving a surface of grating much more extended in proportion, which could be easily got at to remove the deposits whenever they had accumulated sufficiently to obstruct the water.

As to the expense, he thought for the smallest class of houses, consuming only 100 gallons per day, Parkinson's meter would be the cheapest, if the necessity for a cistern and the ascending supply-pipe which it involved were not taken into account; but water meters were scarcely applicable to cases of such small supply. The smallest size made, ½-inch bore, would supply 300 gallons per hour, and cost £3 10s. —a 1-inch meter, for 1200 gallons per hour, £5 5s.,—and a large 10-inch meter, to deliver 100,000 gallons per hour, cost £50 or £60.

Mr. Slate observed that the subject of water supply was a very important one, and a thoroughly good and efficient meter, that would register correctly under any difference of pressure or velocity, without interfering with the pressure, would be a great acquisition, if it were not too expensive for general use, and were safe from derangement in action. He thought they were much indebted to Mr. Siemens for the development of the subject in his paper. Such a meter would be of great value for large establishments, to enable them to get a correct account of the water consumed for different purposes, and would prove an important advantage, both to the consumers and the Water Works Company. But in the case of the smaller classes of houses, he had been led by extensive experience of water supply to the conclusion that the only system practicable was an unlimited supply, and meters were not applicable in such cases, as it would not do to raise questions of dispute about such small water-rents.

The meter brought before the meeting appeared a very ingenious invention, and correct in principle; the only question about it, he thought, was as to the wear and tear, and what effect that might have on its accuracy of measurement. The only point where the degree of pressure could affect it, would be on the end of the spindle in the upper oil chamber, being exposed to the pressure at the lower end; if there was no perceptible difference of wear on the spindle under a 300 feet or a 30 feet head, he did not see there could be any difference in the accuracy of measurement under different pressures.

Mr. Hodge thought the wear would altogether amount practically to a constant quantity, as there was so slight force on all the moving drums and wheelwork, and there could be so little oxidation or friction.

Mr. Siemens said that the amount of pressure was balanced in every part, as the upper oil vessel was also under the pressure; and the extent of reduction of the motion was so great, that no perceptible effect of friction could arise on account of the great leverage, the drums in the water having 20,000 revolutions for one of the index. A great difficulty was experienced with meters having counters working in water, although they might perform very correctly when tested in the shop, and for some time after being fixed; he had always found they became incrusted sooner or later, according to the peculiarities of the water, interfering with the accuracy of working; although brass remained clean much longer than iron, and the deposit was found to take place much less upon the parts in motion than upon those at rest.

Mr. Chellingworth remarked that in Taylor's water meter that was brought before the last meeting of the Institution, he believed that difficulty had not been experienced, though the works were mostly immersed in the water; he knew of several of them that were at work, and had all kept in good order, and he was not aware of any case of a variation of 5 per cent. in the measurement when tried.

Mr. Hodge inquired what objection Mr. Siemens considered there was to the principle of that meter?

Mr. Siemens replied that he thought there would be a source of inaccuracy in the use of the two modes of delivery of the water at different times, the small jet for the slowest velocities, and the full width of orifice for the other cases, as the force of impulse in a small jet was more in the proportion of the square of the velocity, so that a double velocity of jet would drive the drum three or four times faster instead of only twice as fast, which would be required for correct measurement of the stream of water issuing; also the indirect action of the stream on the circumference of the revolving drum, being partly by impulse and partly by friction, gave too uncertain a moving force to form a correct principle of measurement. From his experience he did not think that wheelwork could be kept in correct working order for a long time if exposed to ordinary water, and this difficulty would apply more strongly to any self-acting adjusting valve at the inlet orifice to be

opened by the current of water, and regulate the area of discharge upon the drum.

The CHAIRMAN observed that he had witnessed a trial of Taylor's meter at Manchester, and it seemed to work very correctly, as far as it was tried under different velocities of discharge. He asked if Mr. Taylor had any explanation to offer on the subject?

Mr. TAYLOR said he had not found any difficulty or objection arise in the meters that had been put to work, and they continued to give satisfaction; there were many at work under different circumstances, and they had been found to measure very correctly both under high and low pressure, and when running full bore or only the smallest stream. He had made an improvement in the spring of the regulating valve, since the discussion of the meter at the last meeting, which removed the objection then made against the durability of the india-rubber spring for closing the valve, and this was now effected by a simple adjusting weight screwed on a small lever pressing against the valve. He should be glad to present to the Institution a specimen of the meter with the improved valve.

Mr. HODGE hoped that, as well as the subject of measuring water, attention would also be directed to modes of cleansing the water from the impurities, whether mineral, vegetable, or animal, which were so generally to be met with; he thought some means was much needed for purifying the water efficiently and cheaply, without interfering with the mode of supply.

Mr. SLATE said he expected to be able to show a filter at the next meeting of a simple construction and small size, that would answer the purpose without cutting off the pressure.

Mr. HODGE was glad to hear of the subject being taken up; he should also have a plan to propose for the purpose.

The CHAIRMAN said he thought the paper of Mr. Siemens was a very valuable one, on an important and interesting subject, and proposed a vote of thanks to him, which was passed.

The following paper, by Mr. Joseph Beattie, of London, was then read:—

ON AN IMPROVED LOCOMOTIVE ENGINE.

The economy of fuel in working Locomotive Engines is a subject of great importance to Railway Companies, and has attracted considerable attention for many years; but at no period since the introduction of railways has this subject been of such moment as at the present, by reason of the great demand for coal, and consequent increase of price.

The writer having been connected with one of the metropolitan railways for many years, and coal being so very expensive in the south, was led to the consideration of economy in fuel and the production of steam at the lowest possible cost, the accomplishment of which appeared to be in the employment of coal to be used in a separate and distinct fire-box, but in connection with the coke fire-box of the Locomotive Engine; and this idea was strengthened by the observation of the working of coke ovens in the manufacturing of coke, where he often lamented to see the great amount of flame and combustible gases pass off into the flues and chimney without producing any useful effect; and when it is remembered that $1\frac{1}{2}$ tons of good coking coal is required to produce one ton of coke, some estimate may be formed of the quantity of combustible gases that is thrown off.

Being anxious to secure the advantages which appeared to be got by the use of coal in connection with coke in the generation of steam, the writer considered the proper mode was to use coal and coke in separate furnaces, so arranged that the flame and combustible gases thrown off the coal fire would enter into and pass over that of the coke fire, and entering by short tubes into a combustion chamber, situated partly central between two sets of tubes in the cylindrical portion of the boiler, and where complete combustion would be effected.

A new engine on this principle has not yet been completed, but it has been applied in part to 6 engines with the ordinary boiler on the London and South Western Railway, and the results of working have been found most satisfactory. One of them, the "Britannia Engine," with 15 in. cylinders, 21 in. stroke, and 7 ft. driving wheels, has been working since August, 1853, and run 13,600 miles between Southampton and London, a distance of $78\frac{3}{4}$ miles, taking the regular running of

passenger trains; the average consumption has been 17 lbs. per mile, one third of which was coal, but charged in weight as coke. An experimental trip was made with this engine by Mr. Edward Woods, in October last, with one of the passenger trains to Southampton, and back to London; and another experimental trip was made by Mr. W. P. Marshall, Secretary of the Institution, on the same engine, with the 10 15 a.m. mail train from London to Southampton, on the 17th instant, returning with the 3 0 p.m. train to London; the particulars of these experiments are appended, and the general results are as follows :—

Experiments with the "Britannia" Engine with Passenger Trains, from London to Southampton and back.

	1853. Oct 26	1854. Jan. 17.
Length of double trip, with Train .. .. miles,	157½	157½
„ „ „ Engine .. .. „	161½	161½
Down trip, average train, ... carriages,	12.8	11.2
„ average speed running .. .. miles per hour,	31.4	28.3
„ number of stoppages .. .. No.,	8	8
Up trip, average train,.. .. .. carriages,	18.5	19.3
„ average speed running .. .. .. miles per hour,	29.4	27.5
„ number of stoppages .. .. No.,	7	7
Total consumption of Coke .. .. cwt.,	16	18
„ „ Coal .. .. „	8	8¼
Total consumption per mile of Train, .. lbs. per mile,	17.1	18.6
„ „ per mile of Engine .. .. „ „	16.7	18.2
Water evaporated per lb. of fuel .. .. lbs.,	8.3	8.1
Average pressure of steam, Down trip, ... lbs.,	..	105
„ „ „ Up trip .. .. „	..	100
Greatest pressure during trips .. .. „	..	128
Least „ „ (omitting last 10 miles) .. „	..	82
Average pressure in Up trip over 17 miles, rising 1 in 250, between Bishopstoke and Basingstoke „	..	122

The action of the coal and coke fire-boxes is as follows :—

The coal fire-box A A, Figs. 1 and 2, Plate 5, is attached to the back of the fire-box B B of the ordinary Locomotive Engine, as shown in the plan, Fig. 2, and placed partly below the foot-plate, the water space of which is in connexion with that of the coke fire-box by two branch pipes,

C C, at bottom, and two at top. The flame and combustible gases thrown off the coal fire pass into the coke fire-box through tubes, D D, inserted into the intervening water space; and to promote the combustion of the gases, by giving more time for better admixture, a curved fire-tile bridge E, forming a sort of combustion chamber, is placed within the coke fire-box, fronting the tubes leading from the coal fire-box, thereby checking the velocity of the flame in its passage over the surface of the coke fire. The coal fire-box and the coke fire-box are provided with separate ash-boxes and close fitting dampers, F, G, whereby the draught to each can be regulated with the greatest nicety, and independent of each other. The damper of the coke fire-box, F, is generally kept nearly closed, and is only opened about $1\frac{1}{2}$ inch with trains of 20 to 24 carriages; but the damper of the coal fire-box, G, is generally kept *quite* open, to admit the *full draught* of the blast, by which means, the coal fire being excited to the utmost, the gases and flame pass into the coke fire, and with them the air in a *heated* state; the high temperature of the coke fire is maintained, and more perfect combustion is the result. The combustion of the smoke is completely effected, the smoke being scarcely perceptible. An important practical advantage is gained from the circumstance of the ordinary coke fire-door being kept almost constantly closed, the door being opened only three times to put on coke during the whole trip of $78\frac{3}{4}$ miles, thus preventing the frequent rush of cold air cooling the fire-box and tubes, and causing a liability to leakage: in the present case, all the air entering at the coal fire-door, becomes highly heated before coming in contact with the main fire-box and tubes.

The next subject which attracted the author's attention was the fact that all the water required for the supply of the engine when working was sent cold into the boiler, and to obviate this evil, attempts were made to warm the water in the tender by steam from the boiler *before* the engine started to work, but this was obtained at the *expense* of the fuel, and was only available as far as the first quantity of water in the tender would supply the engine. The next supply of water taken into the tender must be used cold, because the engine being *on the journey* could not afford to part with steam to heat the water, as in the first instance before starting. The great evil of frequent loss of time in

travelling was a consequence of the cold-water system of working, and so much was this felt, that when an engine was heavily loaded and taxed to her *utmost capability*, and having to ascend a long steep gradient, the extra steam to be generated to accomplish this task necessitated an extra supply of *cold* water to be pumped into the boiler, thus checking the generation of steam, reducing the pressure in the boiler, and crippling the engine. This evil being so great, the author attentively reviewed the whole action of the engine, with a view to improvement as well as economy, seeing that nearly the whole of the caloric which had cost so much was finally dismissed as useless at the chimney; it occurred to him that part of such caloric might be intercepted and communicated to the cold water used for supplying the boiler, a source of heat being thus available.

Various apparatus for this purpose have been contrived and put in operation, one of which is that attached to the "Britannia" Engine, which is shown in Plates 6 and 7. It consists of an oblong rectangular chamber H H placed in the smoke-box, and cast in one piece with the exhaust pipe, and communicating to the upper part of the ordinary blast pipe; this chamber is filled with a series of small tubes shown in section in Fig. 4, fixed in tube plates at each end, and communicating with inlet and outlet chambers in connection with the engine, pump, and boiler. A branch pipe I from this rectangular chamber communicates with an outer condensing apparatus fixed in front of the chimney, consisting of three upright pipes K K L standing on a cast-iron foundation, shown in plan in Fig. 6, and connected at top by a hollow cap. Two of these pipes, K K, are provided with jets or injections supplied by the cold-water pump, which draws its supply direct from the tender. There is an overflow pipe M, for conveying the water after it is heated to the hot-water pump, and an overflow pipe N N leading into the tender to convey any surplus water which may not be taken by the hot-water pump. The third upright pipe, L, is provided with a disc, or throttle valve O, by which the exhaust steam from the lower chamber H H can be admitted into the condenser. P P is an air pipe inserted in the centre of the orifice of the blast pipe, with a funnel-shaped mouth at the lower end, to catch the air and assist the blast.

The action of the apparatus is as follows:—When the engine is

working, the exhaust steam from the exhaust steam pipe, before it reaches the orifice of the blast pipe, fills the lower chamber, forming a steam bath around the small tubes (through which the water passes into the boiler), and flows upwards into the outer condenser, where it is condensed by the jets from the cold water pump, and such water, together with that obtained from the condensed steam falling to the bottom of the condenser, is carried off by the overflow pipe before named to the hot water pump, which propels it through the small tubes in the lower chamber; and as the water passes slowly through these pipes on its way to the boiler, it absorbs heat from the constant supply of steam rushing to the condenser to be condensed, and enters the boiler at a very *high* degree of temperature, and causing little or no check to the generation of steam in the boiler, thereby maintaining the *full power* and energy of the engine. The average pressure in the experiment throughout the whole down trip was 105 lbs., and 100 lbs. in the up trip; the total fluctuation in pressure during the trip being very limited.

This is a desideratum of no small value, and is experienced especially in the working of the engine between Southampton and London, as there are many *long* and *sharp* gradients, particularly that between Bishopstoke and Basingstoke, the gradient averaging 1 in 250 for 17 miles; the Southampton, Portsmouth, Gosport, and Salisbury trains, being all joined at Basingstoke, and taken in one train to London, which generally contains from 20 to 26 carriages. The advantages of the improvements just described are particularly apparent whilst ascending this *long* gradient, as was shown in the experiment last referred to, in which a uniform pressure of 120 lbs. per square inch was maintained up this incline of 17 miles 1 in 250, with a load of 21 carriages; in consequence a high rate of expansion could be employed throughout, the steam being cut off at 5 inches out of 21 inch stroke, or at less than 1-4th of the stroke during the whole time, an important source of economy.

There are 6 engines, adapted for burning coal and coke upon this principle, working on the London and Southampton line (the "Britannia" being one of them), whose united running amounts to 100,360 miles, and the average consumption of fuel, coal and coke together, has been 15.6 lbs. per mile, the "Britannia" having run 13,600 miles with an average consumption of fuel of 17 lbs. per mile. In

conclusion it may be remarked that in *no one* instance have any of these engines failed in *any* part of the apparatus connected with these improvements; also the same remark applies to the 14 other engines (although in daily use) which are furnished with the heating and condensing apparatus. Should any mishap occur, the engine-driver can cut off the communication from the heating apparatus in an instant, and supply the boiler and work the engine in the ordinary way, and without stopping the train.

The CHAIRMAN observed that the subject of the economy of fuel was of great importance in locomotive expenditure, the cost of fuel being the largest item, and if a cheaper fuel than coke could be efficiently used, it would prove a great saving in expense.

Mr. COWPER said he was present at the trial of the new engine on the 17th instant, mentioned in the paper, and accompanied the engine throughout the trip, and he could corroborate the account of the experiment given in the paper. The engine worked very efficiently, and the uniformity was remarkable with which the full supply of steam was maintained; a steady pressure of 120 lbs. per inch being maintained up the heavy incline of 1 in 250 for 17 miles with the load of 21 carriages. There was no difficulty caused by the use of coal, and the smoke was quite consumed, though the coal amounted to one third of the whole fuel.

Mr. SLATE inquired what was the comparative result of the previous working of the engines with coke, and the ordinary construction?

Mr. BEATTIE replied that he had not made an exact comparison with the other engines, but he thought about 24 lbs. per mile of coke was the usual consumption with similar work. The "Britannia" engine that had been experimented upon was a new engine that had not been previously worked with coke, but there was the means of readily making an accurate comparison, as the heating apparatus could be entirely disconnected, and the engine worked with the ordinary feed, and with coke just like ordinary engines.

Mr. HODGE inquired whether the combustion of the coal was found to be quite complete, and whether there was any smoke visible at any time?

Mr. Cowper said the combustion of the smoke was practically perfect; he had watched the engine carefully, and thought once or twice there was a slight trace in the steam, but if there was any it was so slight that it would certainly not have been observed if attention had not been directed to it.

Mr. Hodge suggested a trial of anthracite coal for the purpose, as it was used successfully in America for locomotive engines by means of a peculiar construction of furnace, and it was free from smoke. The consumption of the smoke was a question of great importance for all kinds of engines, and as it would prove so decided an economy of fuel to the proprietors, as well as a great benefit to the public by purifying the air, he hoped it would be enforced generally.

The Chairman observed that he thought it very probable, from official communications he had been engaged in, that there would be some strict enactment before long to enforce the general consumption of smoke. Wherever there was smoke it was clear there must be imperfect combustion, and therefore a loss of fuel to the proprietors; so that the smoke burning, or rather the prevention of smoke, would economise the consumption of fuel, though it might undoubtedly lead in some cases to larger boilers being required where the present boilers were overworked, and, in consequence, expensively worked. In Manchester there had been strict regulations in force for many years, to check the quantity of smoke, and regular inspectors were appointed to carry them out; any chimney was reported that emitted black smoke for longer than three minutes after firing, and they were limited at other times by strict regulations to what was styled "Parliamentary smoke," or such that allowed an object being seen through it. The efficiency of the regulations was shown by the circumstance that the steam engines in Manchester had doubled of late years, whilst the smoke was certainly very much reduced.

Mr. Hodge remarked that in Cornwall, where fuel was so expensive, the economy of smoke consumption was fully understood and practised; and hundreds of engine chimneys might be seen giving no sign by smoke that they were at work. The engineers had to pay for the coals they used, and had therefore a direct interest in the saving of fuel.

Mr. Slate observed that the smoke burning depended greatly on the care and habits of the men; and the Cornish chimneys would

doubtless smoke if the boilers were put in the hands of ordinary Staffordshire stokers.

Mr. Siemens remarked that the practicability of consuming the smoke was proved satisfactorily by several engine chimneys in London; a large one in his neighbourhood that he had frequently noticed, erected by Mr. Cowper, had generally no smoke visible, and he had never seen any from it for more than a few minutes. He had also witnessed the trial of the locomotive engine described in the paper, and could bear witness to the total absence of smoke during the whole time, unless perhaps the faintest trace when putting on fresh coal; the mode adopted for burning coal in a locomotive engine was certainly very successful. The heating apparatus was also very efficient in saving part of the heat usually thrown away, and consequently economising fuel; the water in the tender was heated up to 120°, but the feed water would be considerably hotter when pumped into the boiler, and probably at 180°, or nearly boiling.

Mr. Clark said he had made a trial of the same engine yesterday from London to Southampton and back, and the results were certainly very satisfactory. The chimney was quite free from smoke, except perhaps when feeding with mere dust, and there was no difficulty or objection apparent from the use of coal; the work of firing, by the separation in the tender of the coke and coal, was quite as easy, or rather more so, than in the ordinary engines. The consumption was certainly below the average, though part of the fuel was coal; he had compared the results of the trial with many experiments he had made with different engines, and the consumption was 3 or 4 lbs. per mile below their general average with similar work; but he was not prepared to say how much of the economy was due to the plan of fire-box, and how much to the apparatus for heating the feed water. The large fire-box was, he considered, unfavourable to the economy of the engine, the consumption being only about 30 lbs. per square foot of grate per hour, and he should therefore expect still better results to be attainable with a different proportion of fire-box.

Mr. Beattie said that the trials at present made of the principle had only been carried out by an application to existing engines without alteration, as shown in the drawings, by means of which the principle might be readily applied to any engine without inconvenience or injury.

He was however building a new engine for a thorough trial of the principle, with a smaller coke fire-box, and the coal fire-box could be turned within, making together one large box with two fire-doors. He intended also to have the tubes divided into two lengths by having a combustion chamber (surrounded with water) in the middle of the boiler, for the more complete combustion of the gases evolved from the coal by the admission of air into the chamber, which was divided by fire-brick or other bridges, to distribute the currents of gases.

The heating apparatus for the feed water, he considered an important source of economy in fuel, by seizing a considerable quantity of the heat that was ordinarily thrown away in the exhaust steam, and returning it to the boiler; it was in fact a partial condenser applied to the engine, and the full economy of fuel was not shown by the proportion of water evaporated from the tender per pound of fuel, because a great portion of the steam was condensed and returned to the boiler at each stroke, and evaporated over again, causing a much less supply of water to be required from the tender. They had not experienced any difficulty in keeping the feed pump at work with the hot water, as the water ran down into the pump; one pump only was ordinarily employed for feeding the boiler, being made rather larger than usual, and the other pump was employed entirely in driving the water through the heating vessel before it entered the feed-pump. The feed-pump was kept very uniformly in constant work during the journey, and the ordinary cold feed could be turned on to it at any moment, by a branch cock, if required from the pump getting too hot to work properly.

Mr. Hodge suggested that it would be desirable to make a careful trial of the coal-burning apparatus alone, without the heating apparatus, for the purpose of ascertaining separately the economy derivable from it.

Mr. Beattie said this comparative trial could readily be made, without alteration of the engine, and consequently with complete accuracy, by shutting off the heating apparatus; as by merely reversing the threeway cock and shutting the escape valve at the blast pipe, the engine was made to work exactly like an ordinary one. He hoped that some of those members who had already tried the engine, would make a further experiment to ascertain this point.

Mr. Cowper remarked that it should be noticed that the gross

consumption of 18.4 lbs. per mile obtained in the experiment, really amounted to only 15.3 lbs. per mile commercially, in comparison with ordinary coke-burning engines, taking into consideration the relative value of the coke and coal, as one third of the fuel was coal, and about $1\frac{1}{2}$ tons of coal was required to make 1 ton of coke, to which was to be added the cost of making the coke. This showed a very important saving in expense of fuel, and he did not see any difficulty in carrying the economy still farther by increasing the proportion of coal.

The CHAIRMAN said that it was certainly a very important and interesting subject, and they were indebted to Mr. Beattie for the information he had brought before them, and he hoped he would communicate to the Institution the results of his further trials. He proposed a vote of thanks to Mr. Beattie for his paper, which was passed.

The following paper, by the Secretary, was then read:—

ON BERDAN'S CRUSHING AND AMALGAMATING MACHINE.

The remarkable progress made in gold discovery during the last few years gives an interest to mechanical appliances for securing the precious metal by the complete reduction of its ores. This machine for pulverising, washing, and amalgamating gold ores has recently attracted much attention from its mechanical merits, and its success in working.

Gold is found in a great variety of forms in the different quarters of the world, and means as various have been applied to secure it. In Africa, the small particles known in commerce as "gold dust," are collected by a rude process of washing. In the Ural it is found in small pieces imbedded in gravel, as well as in veins in quartzose rocks; it is sometimes associated with platinum.

In North and South America it is brought down in streams from the mountains, sometimes in the shape of sands, and at others in small lumps or nuggets. In Mexico it is generally found associated with silver; but the most constant source of the metal is the parent rock, to which recourse is always had when the secondary supplies found in sands and clays begin to fail.

These rocks are found abundantly in Russia, Australia, and California, and are supposed to exist in considerable quantities in Great Britain. The most prolific and certain of the British rocks thus far tried have been the gozzans, which, though not rich, are soft, and easily worked.

Notwithstanding the general diffusion of gold-bearing ores throughout the world, the problem of their complete and economical reduction long remained unsolved. A great many attempts have been made, and processes more or less efficient were adopted, but none of them approached complete success; all the plans, whether by washing, smelting, or amalgamating, failed to produce a perfect result. In washing, a considerable portion of the metal escaped with the waste water; in amalgamating, which involves previous pulverising, the ore was not ground to sufficient fineness, and was not thoroughly brought into contact with the mercury. The result of these imperfections was a loss of one third to one half the gold known by assay to exist in the ores.

The inventor of the machine, the subject of the present paper, had his attention called a few years ago, as a practical mechanical engineer, to the serious loss of the precious metal which was entailed upon the Californian gold seeker by the imperfection of the best appliances he could bring to bear upon his work. Determined if possible to remedy the evil, Mr. Berdan, in 1851, sent to California two practical engineers for the purpose of examining all the machinery there in use, and ascertaining from the mining people themselves what were the difficulties to be overcome, and what were the best means then at their disposal. All agreed that their best machines lost from 30 to 50 per cent. The only process on which they could rely, was applicable only on a very small scale; that was known as the "miner's assay," because it was the mode adopted at the diggings for testing the richness of the ore before beginning to work it. In this process mercury is put in a mortar, the ore to be tested is thrown in and covered with *hot water*, and the pulverising is completely effected by the weight and combined rolling and grinding or rubbing action of the spherical end of the pestle, while the mercury is kept at the point of crushing, and is heated by the bottom of the mortar, which is kept hot by the

boiling water contained in it. From this simple but perfectly effectual process are learned the following principles, on which a perfect gold-reducing machine should operate.

1.—It should grind the ore to an impalpable powder, in order to perform which, it should have a combined rolling and rubbing action;—without perfect pulverising, the metal would not be effectually exposed to the action of the mercury.

2.—It should amalgamate at the *instant* of crushing; otherwise the small particles of gold may escape, by floating off on the waste water, or by becoming coated with the mud or refuse, and thus protected from the action of the mercury.

3.—The amalgamation should take place at the *point of crushing*, or below the surface of the mercury; and in order to do this, the mercury must be kept constantly at the crushing point. This is of great importance, as the surface of mercury is covered at all times with a film of oxide, which must interfere materially with the perfection and rapidity of its action in amalgamating. But in addition to this, it is always covered in practice with the mud and refuse from the grinding operation, which much increases the difficulty of bringing the finely-floured gold into perfect contact with the mercury; at the bottom of the mercury, where it is perfectly pure, both of these difficulties disappear.

4.—It should heighten the affinity between the mercury and the gold by the addition of heat. The increase of affinity produced by heat may be illustrated by dipping a sovereign in a spoonful of cold mercury and observing how much it will take up, then heating the mercury over a lamp and noticing the greatly-increased quantity that will cling to the coin.

5.—It should lose no mercury in the process. The loss of a material so expensive has been a serious evil in amalgamating machines. It has hitherto been broken up in the process of grinding, and passed off in a finely-divided state with the refuse.

These *five* principles are found in the miner's assay, and to combine them in a machine on a large scale was the object Mr. Berdan had in view in the invention of his apparatus. This object he has attained, with the additional advantage of avoiding the expense which must attend the heating of water in large quantities.

The construction of the apparatus is simple, and is shown by the drawings and models exhibited. The machine in its present form is a great improvement on the first one made by Mr. Berdan. The first machine which was exhibited at work in America, in December, 1852, had but one ball, which weighed only 1700 lbs., and was attached by a universal joint to the central shaft. Several of these machines were put to work, but although they were more efficient than machines before used, especially when employed upon refuse or "tailings" which had already been partially pulverised, they were considered as too small, and far from perfect. A few of them were set up in California and North Carolina, and obtained from "tailings" supposed to be practically exhausted, 19 per cent. of the original riches of the ore. Only eight of these small machines still remain in use, all the others having been exchanged for the large and improved machines now at work in England. The first improvement made on the small machines was increasing the ball to three times its original weight. It was still, however, left attached to the centre shaft. A great increase of efficiency was the immediate result of this modification. The small ball which had been rejected, was on one occasion, and merely as a matter of curiosity, placed in the basin behind the large one, when it was found to steady the motion and greatly increase the rapidity of the reduction. Finally it was determined to disconnect the large ball from the shaft, and run both balls loose. This was tried, and the result was perfectly satisfactory, and left the large machine in its present condition, as shown in Figs. 1 and 2, Plates 8 and 9.

It consists mainly of a cast-iron basin, AA, 7 feet in diameter, revolving upon an inclined axis or shaft BB. In this basin are placed two cast iron balls C D; the larger one 34 inches in diameter, and weighing 2½ tons, the smaller one 24 inches in diameter, and weighing 1 ton. Under the basin, and attached to and revolving with it, is a furnace EE, of conical form. The whole being in a strong framework of timber, receives motion from hand, horse, or steam power by means of a bevil wheel gearing into teeth cast upon the underside of the basin at FF. The operation is as follows:— Fire is made in the furnace beneath the basin, and the ore thrown in, in lumps of considerable size. The apparatus is then set in

motion; the balls, by their gravity, revolving in a direction opposite to that of the basin. The two balls, moving in contact with each other and with the inclined bottom of the basin, receive a spiral as well as a rotary motion—a combination which is found to possess the greatest efficiency in the pulverising of the ore. The ore is brought under the balls and instantly crushed to an impalpable powder, the crushing being effected at the point of contact between the large ball and basin, and below the surface of the mercury. Thus, the moment the gold is disengaged, it comes in contact with pure and heated mercury, which seizes upon and secures it. The refuse powder rises to the surface of the quicksilver, whence it is carried off, in the form of a thin paste, by a small stream of water, which runs in at the upper side of the basin, and escapes through suitable openings G G, just below its rim, into a trough placed for the purpose. The tailings or refuse may thus be preserved for analysis if desired. When the ore has all passed beneath the balls and been crushed, the refuse is rapidly washed out of the basin by a free supply of water. The mercury having been drawn from the basin by means of a hole N in its bottom, stopped by a wooden plug, is strained through a skin of washleather to separate the amalgam which it contains. The quicksilver is then driven off by applying heat in an ordinary crucible, when the gold alone remains. This is the rough method used in experiments made on a small scale, where it answers very well, as the mercury sublimed and lost does not exceed in weight the gold produced; but on a large scale the whole of the mercury used in the operation is distilled in a retort, which saves at once all the mercury and all the gold. When this process is not used, all the gold is not secured, as a portion of it remains in the mercury. It is an interesting fact that mercury thus holds in suspension a portion of the precious metal, and that the quantity thus absorbed is not a definite, but a variable proportion, depending upon conditions which have not, it is believed, been satisfactorily ascertained. The loss of mercury by the process is stated by Professor Ansted to be inconsiderable, not exceeding the weight of gold yielded.

The time consumed in washing out the basin and withdrawing the amalgam is about half-an-hour, but the process need be performed in practice only once or twice a week.

It is to be observed that this machine is not simply a crusher, but that it does *all the work* necessary to secure the desired product in combination with mercury. It crushes, washes, and amalgamates at one and the same operation. The simplicity and durability of its parts, small amount of friction in its gearing, and the moderate power required to work it, render it an important addition to mining machinery.

It is found that a machine consisting of four basins in one frame, will pulverise, wash, and amalgamate about 20 tons of ore, of average hardness, in ten hours, with from 15 to 20 horse power. Any number of basins can be used in one frame, and driven by one main shaft.

The peculiarity of this invention does not consist in the use of balls and basins, but in the inclining of the shaft on which the basin revolves, which keeps the mercury always at the crushing point, and causes the balls to work by gravity;—in the production of a combined rolling and grinding action by the contact of the balls;—and in the addition of heat to the mercury by means of the furnace below the basin, increasing the chemical affinity of the mercury and the gold. By the inclination of the basin the mercury and balls are kept always at the lowest point of the basin, and thus the amalgamation is insured at the instant and at the point of crushing, and below the surface of the mercury. The heating of the mercury is also facilitated by this arrangement; for it is obvious that if the bottom of the basin were horizontal, and fire were applied below, the heat would pass through the iron and the mercury to the water above, leaving both metals comparatively cold; but by the inclination of the basin, the bottom is exposed for more than half of each revolution to the direct action of the fire, without having water above to carry off the heat. Thus when it passes at a high temperature under the mercury, it effectually communicates heat to that metal, and places it in the best condition for seizing upon the gold as fast as it is liberated.

This "crushing machine" has attached to it an auxiliary machine called a "separator," which entirely prevents loss of mercury, and is as simple in its construction as the principal machine. A section

of it is shown in Fig. 3, Plate 9. A tub of cast iron, HH, is constructed 24 in. in diameter, and 20 in. high. In the centre of this tub is placed an upright tube, I I, 3 inches in diameter, having at its lower end horizontal hollow arms, K K, attached at right angles to the tube. These arms have at their ends, and on one side, narrow slots or elongated openings. Around the upright tube is placed a casing, LL, which revolves upon it. To this casing are attached vertically, adjustable wings or slats, M M. The casing with its wings is revolved in an opposite direction to the tube and its arms, by means of a bevil driving wheel attached to the main shaft, and working into wheels of similar bevil, attached at a proper distance apart, one to the casing and the other to the tube. The mode of the operation of the machine is as follows:—A quantity of mercury several inches deep is placed in the bottom of the tub; the wings of the casing are then so adjusted that they will just clear the surface of the mercury when the machine is in motion. The driving shaft being put in motion, the tube and arms revolve, as before stated, in a direction opposite to that of the casing and wings. The pulverized ore or refuse from an amalgamating machine, in suspension in water, is fed in through the tube, and passes into the arms at its bottom, whence it is driven by centrifugal force through the narrow slot-shaped openings at the end and back part of the arms, and passes forcibly out in a thin sheet underneath the mass of mercury in the bottom of the tub.

This mercury, by affinity, retains all the floured mercury which may have been broken up in the process of amalgamating, and seizes upon all particles of gold which may have escaped the previous operation, while the pulverized matter, suspended in water, rises to the top of the mercury, and being kept in suspension by the operation of the wings, is driven to the top of the tub, and passes off through an exit spout. The use of this machine need not be confined to the separation and saving of floured mercury, but it may also be employed as an independent amalgamator.

In reference to the comparative expense of the process, the most unfavourable estimate that has been made on this point is that of Professor Ansted, who states the case as follows:—

PLANT.—Cost of a nest of 4 basins . .	£2400		
Conveyance to mine, foundations and fittings, house, &c.	300		
		2700	
Cost of a 25 horse power engine, complete	1250		
Engine and boiler house . .	150		
		1400	
Sundry incidental charges . .		100	
Total cost of plant . .		£4200	
ANNUAL CHARGES.—Deterioration and replacement of machine, 60 per cent.		£1440	
Ditto ditto of engine and fittings, 10 per cent.		150	
Interest on cost of plant, at 5 per cent. . .		210	
Total annual charges		£1800	
DAILY CHARGES.—Proportion of annual charges on each working day	£6	0	0
Wages and salaries per day, working day and night	2	10	0
Coal, 2½ tons at 15*s*.	1	17	6
Oil, waste, tallow, tools, and sundries .		2	8
Loss of mercury, and proportion of laboratory expenses		4	6
Crushing 16 tons, at 4*d*. per ton . . .		5	4
Average daily charges. . . .	£11	0	0

The four basins crushing and amalgamating not less than 16 tons, on an average, per working day, the mean cost would thus be 13s. 9d. per ton.

Mr. Readwin, after 12 experiments, estimated the cost at 2s. 6d. per ton. The cost would probably vary from 5s. to 10s. per ton, according to the hardness of the ore operated upon.

About 600 trials of ores, gozzans, and mundics, mostly British, have been made with these machines since the 24th of October last, when they were first worked in London. In most of these trials gold has been produced, in quantities varying from a mere trace up

to several ounces per ton. The gozzans have been remarkable for the regularity of the yield. The results of such a large number of trials, most of them public, would seem to settle the long-agitated question of the existence of gold in England in remunerative quantities; three dwts. to the ton will fully pay the cost of reduction, while most of the ores yield from 15 to 30 dwts. per ton.

The Secretary stated that he had witnessed the satisfactory working of the machine in London, from which the drawings were taken, and Mr. Stansbury, of London, by whom the particulars in the paper had been supplied, had attended the meeting for Mr. Berdan, to supply any further information that might be desired.

Mr. Stansbury exhibited two working models of the machine, one with a single basin, and the other with a pair of basins. He explained that the machine now working in London had been brought from America, where it had been worked very successfully for about six months previously; and a number of them were working in California, and were found a great source of gain by their simple and efficient action, and by separating so much more of the gold from the ore than could be accomplished by any other means. The machine in London had been working for some months upon a very extensive series of specimens of ores, &c., sent from all parts of this country, and the results were very remarkable as showing the very general diffusion of gold throughout the country, and the power of the machine in extracting and rendering serviceable the most minute portions of the precious metal.

He showed the results of Professor Ansted's examination into the working of the machine and estimate of its expenses and profits, and stated that he thought the amount set down in the estimate for wear and tear would prove considerably too great, the depreciation having been taken at 60 per cent. per annum, amounting to under two years lifetime. He thought the duration of such a very strong and simple machine must be much greater than two years; and the very machine now at work in this country, though it had been six months at work previously in America, had scarcely the roughnesses of the casting worn smooth yet.

Mr. Slate remarked that the depreciation would not appear to be so much over-estimated when it was considered that in mortar mills and

similar heavy machines with a grinding and twisting action, it was found that they did not generally last longer than about three years. The cost of renewal would however be at a considerably lower rate than the first cost, as that included the patent right, which he supposed would not be charged again on any subsequent renewals of the machine.

Mr. STANSBURY replied that the expense of repairs would be simply the cost of the renewals, the charge for patent right applying only to the first cost of the machine.

Mr. MORRIES STIRLING inquired whether any effect was produced upon the iron basin by the combined action of the mercury and the heat?

Mr. STANSBURY replied that no effect from the mercury had been noticed.

Mr. COWPER said he had recently seen the machine in action, in London, and it certainly performed the work very efficiently; the peculiar grinding and crushing action of the balls, caused by their compound motion, was a very complete and mechanical contrivance for the purpose of pulverising the ore, and the inclined position of the basins assisted the process materially, by causing the gold to be crushed out under mercury.

The machine reminded him of an old one described in White's "Century of Inventions," for the purpose of grinding colours or drugs, in which the basin and ball were nearly similar, but there was an additional motion given to the basin-shaft, namely, an oscillating motion, thus causing the basin to wear more equally, as the ball did not always run in one track.

The CHAIRMAN observed that the machine was a very ingenious and interesting invention, and appeared well adapted to effect an important improvement and economy in the process; they were much indebted to Mr. Stansbury for his attendance, and the excellent models he had supplied for the meeting, and he proposed a vote of thanks to Mr. Stansbury, which was passed.

Mr. SIEMENS moved a vote of thanks to the Secretary for the efficient manner in which he had discharged the duties of his office, particularly in the completeness and promptness with which the

reports of Proceedings of the Institution were published, and the active assistance rendered to the Members in preparing papers for the meetings. The motion was seconded by Mr. Hodge, and passed.

The meeting then terminated, and in the evening a number of the Members and their friends dined together in celebration of the Seventh Anniversary of the Institution.

INSTITUTION OF MECHANICAL ENGINEERS.

BALANCE SHEET.

For the year ending 31st December, 1853.

Dr.	£	s.	d.
To Balance 31st December, 1852.	173	1	3
„ Subscriptions from 11 Members in arrear . . .	33	0	0
„ ditto from 158 old Members for 1853	474	0	0
„ ditto from 23 new Members for 1853	115	0	0
„ ditto from 1 new Life Member for 1853 . . .	32	0	0
„ ditto from 2 old Graduates for 1853.	4	0	0
„ ditto from 1 Member in advance for 1854 . . .	3	0	0
„ Sale of Extra Engravings	2	12	6
„ „ Reports	40	5	9
	£876	19	6

Cr.	£	s.	d.
By Printing and Engraving Reports of Proceedings .	99	5	6
„ Stationery and Printing	19	10	10
„ Office Expenses and Petty Disbursements . . .	23	19	10
„ Furniture	3	0	0
„ Travelling Expenses	5	2	11
„ Parcels	4	15	9
„ Postages.	24	9	5
„ Salary	388	7	0
„ Rent and Taxes.	113	15	6
„ Balance 31st December, 1853.	194	12	9
	£876	19	6

16*th January*, 1854.

(Signed) J. E. CLIFT, ARCHIBALD SLATE, } *Finance Committee.*

SUBJECTS FOR PAPERS.

STEAM ENGINE BOILERS, particulars of construction—form—heating surface—relative value of radiant surface in effect and economy—cost—consumption of fuel—evaporation of water—pressure of steam—steam gauges, high pressure and low pressure—explosion of boilers, and means of prevention—effects of heat on the metal of boilers, low pressure and high pressure—incrustation of boilers, and means of prevention—evaporative power and economy of different kinds of fuel, coal, wood, charcoal, peat, patent coal, and coke—moveable grates, and smoke-consuming apparatus, facts to show the best plan, and results of working.

STEAM ENGINES, expansive force of steam, and best means of using it—power obtained by various plans—comparison of double and single cylinder engines—comparative advantages of direct acting and beam engines—indicator figures from engines, with details of useful effects, consumption of fuel, &c.—contributions of indicator figures for reference in the Institution.

PUMPING ENGINES, particulars of various constructions—size of cylinder and pumps—strokes per minute. and horse-power—number and size of pumps, and strokes per minute—comparison of double-acting and single-acting pumping engines—particular details of different valves—application of pumps—fen-draining engines—comparative advantages of scoop wheels and centrifugal pumps, lifting trough, &c.

BLAST ENGINES, best kind of engine—size of cylinder, strokes per minute, and horse-power—details of boilers—size of blowing cylinder, and strokes per minute—pressure, and means of regulating the blast—improvements in blast cylinders—rotary blowing machines.

MARINE ENGINES, power of engines in proportion to tonnage—different constructions of engines—dynamical effect compared with indicator figures—comparative economy and durability of different boilers, tubular boilers, flat flue boilers, &c.—weight of machinery and boilers—kind of paddle wheels—speed obtained in British war steamers, in British merchant steamers, and in Foreign ditto, with particulars of the construction of engines with paddle wheels, &c.—screw propellers, particulars of different kinds, improvements in the form, number of arms, material, means for unshipping, horse-power applied, speed obtained, section of vessel—iron and wood ships, details of construction, lines, tonnage, cost, &c.

ROTARY ENGINES, particulars of construction and practical application—details of the results of working.

LOCOMOTIVE ENGINES, express, passenger, and luggage engines—particulars of construction, details of experiments, and results of working—speed of engines, cost, power, weight, steadiness—consumption of fuel—heating surface, length and diameter of tubes—experiments on size of tubes and blast-pipe—comparative expense of working and repairing—best make of pistons, valve gear, expansion gear, &c.

CALORIC ENGINES, and Engines worked by Gas, Gun-cotton, or other explosive compounds—comparative consumption per horse-power per hour.

ELECTRO-MAGNETIC ENGINES, particulars and results.

WATER-WHEELS, particulars of construction and dimensions—form and depth of buckets—head of water, velocity, per-centage of power obtained—turbines, construction and practical application, power obtained, comparative effect and economy.

WIND MILLS, particulars of construction—number of sails, surface and form of sails—velocity, and power obtained—average number of days' work per annum.

CORN MILLS, particulars of improvements—power employed—application of steam power—results of working with an air blast and small stones—advantages of regularity of motion.

SUGAR MILLS, particulars of construction and working—results of the application of the hydraulic press in place of rolls.

SAW MILLS, particulars of construction—mode of driving—power employed—particulars of work done—best speeds for vertical and circular saws—form of saw teeth—saw mills for cutting ship timbers—veneer saws.

OIL MILLS, facts relating to the construction and working, by stampers and by pressure.

COTTON MILLS, information respecting the construction and arrangement of the machinery—power employed, and application of power—cotton presses, mode of construction and working, power employed—improvements in spinning and carding machinery, &c.

MACHINERY for manufacturing Flax, both in the natural length of staple and when cut.

ROLLING MILLS, improvements in machinery for making iron and steel—mode of applying power—steam hammers—piling of iron—plates—fancy sections.

STAMPING AND COINING MACHINERY, particulars of improvements, &c.

PAPER-MAKING AND PAPER-CUTTING MACHINES, ditto ditto

PRINTING MACHINES, ditto ditto

CALICO-PRINTING MACHINERY, ditto ditto

WATER PUMPS, facts relating to the best construction, means of working, and application—best forms—velocity of piston—construction of valves.

AIR PUMPS, ditto ditto ditto

HYDRAULIC PRESSES, facts relating to the best construction, means of working, and application.

ROTARY AND CENTRIFUGAL PUMPS ditto ditto ditto

FIRE ENGINES, ditto ditto ditto

SLUICES AND SLUICE COCKS, ditto ditto ditto

CRANES, ditto ditto ditto

STEAM CRANES, HYDRAULIC CRANES, PNEUMATIC CRANES, ditto

LIFTS FOR RAISING TRUCKS, &c. ditto ditto ditto

LATHES, PLANING, BORING, AND SLOTTING MACHINES, &c., particulars of improvements—description of new self-acting tools.

TOOTHED WHEELS, best construction and form of teeth—results of working—power transmitted.

DRIVING BELTS AND STRAPS, best make and material, leather, rope, wire, gutta percha, &c.—comparative durability, and results of working—power communicated by certain sizes.

DYNAMOMETERS, pressure-gauges, governors, construction and working.

STRENGTH OF MATERIALS—facts relating to experiments on ditto, and general details of the proof of girders, &c.—girders of cast and wrought iron, particulars of different constructions, and experiments on them—best forms and proportions of girders for different purposes—best mixtures of metal—mixture of wrought iron with cast.

DURABILITY OF TIMBER of various kinds—best plans for seasoning timber and cordage—results of Kyan's, Payne's, Bethell's, and Burnett's processes, &c.—comparative durability of timber in different situations.

Corrosion of Metals by salt and fresh water, and by the atmosphere, &c.—facts relating to corrosion, and best means of prevention—means of keeping ships' bottoms clean.

Alloys of Metals—facts relating to different alloys.

Friction of various Bodies—facts relating to friction under ordinary circumstances—friction of iron, brass, copper, tin, wood, &c.—proportion of weight to rubbing surface—best forms of journals, and construction of axle-boxes, &c.—lubrication, best materials and means of application, and results of practical trials—best plans for oil tests.

Iron Roofs, particulars of construction for different purposes—durability in various climates and situations—comparative cost, weight, and durability—roofs for slips of cast-iron, wrought-iron, timber, &c., best construction, form, and material—details of large roofs, and cost.

Fire-proof Buildings, particulars of construction—most efficient plan—results of trials.

Chimney Stacks of large size, particulars, mode of building, cheapest construction, &c.

Bricks, manufacture and durability—hollow bricks, fire-bricks, and fire-clay—perforated bricks, cost of manufacture, and advantages.

Gas Works—best form, size, and material for retorts—construction of retort ovens—quantity and quality of gas from different coals—oil gas, water gas, &c.—improvements in purifiers, condensers, and gas-holders—wet and dry gas-meters—pressure of gas, gas-exhauster—gas-pipes, strength and durability, and construction of joints—proportionate diameter and length of gas-mains, and velocity of the passage of gas—experiments on ditto, and on the friction of gas in mains, and loss of pressure.

Water Works—facts relating to water works—application of power, and economy of working—proportionate diameter and length of pipes—experiments on the discharge of water from pipes, and friction through pipes—strength and durability of pipes, and construction of joints—relative advantages of stand-pipes and air-vessels.

Well Sinking, and Artesian Wells, facts relating to.

Coffer Dams and Piling, facts relating to the construction.

Piers, fixed and floating, and Pontoons, ditto ditto

Pile-Driving Apparatus, particulars of improvements—use of steam power—Potts' apparatus—the compressed air system.

Dredging Machines, particulars of improvements—application of dredging machines—power required, and work done.

Diving Bells and Diving Dresses, facts relating to the best construction.

Cast-iron and Wrought-iron Lighthouses, ditto ditto

Mining Operations, facts relating to mining—means of ventilating mines, use of steam jet and ventilating machinery—mode of raising materials—mode of breaking, pulverising, and sifting various descriptions of ores.

Blasting, facts relating to blasting under water, and blasting generally—use of gun-cotton, &c.—effects produced by large and small charges of powder.

Blast Furnaces—consumption of fuel in different kinds—burden, make, and quality of metal—pressure of blast—horse-power required—economy of working—improvements in manufacture of iron—comparative results of hot and cold blast.

Puddling Furnaces, best forms and construction—worked with coal, charcoal, &c.

Heating Furnaces, best construction—consumption of fuel, &c.

Smiths' Forges, best construction—size and material—power of blast—hot blast, &c.

Smiths' Fans, and Fans generally, best construction, form of blades, &c., with facts relating to the amount of power employed and the per-centage of effect produced.

Coke and Charcoal, particulars of the best mode of making, and construction of ovens, &c.

Railways—construction of permanent way—section of rails, and mode of manufacture—experiments on rails, deflection, deterioration, and comparative durability—material and form of sleepers, size, and distances—improvements in chairs, keys, and joint fastenings—permanent way for hot climates.

Switches and Crossings, particulars of improvements, and results of working—advantages obtained by steeling points and tongues.

Turn-Tables, particulars of various constructions and improvements.

Signals for Stations and Trains, and self-acting signals.

Breaks for Carriages and Waggons, best construction.

Buffers for Carriages, &c., and Station Buffers—different constructions and materials.

Springs for Carriages, &c., buffing and bearing springs—particulars of different constructions and materials, and results of working.

Railway Wheels, wrought-iron, cast-iron, and wood—particulars of different constructions, and results of working—comparative expense and durability—wrought-iron and steel tires, comparative economy and results of working—solid wrought-iron wheels.

Railway Axles, best description, form, material, and mode of manufacture—comparison of solid and hollow axles.

The Council invite communications from the Members and their friends on the preceding subjects, and on any Engineering subjects that will be useful and interesting to the Institution;—also presentations of Engineering drawings, models, and books for the library of the Institution.

The communications should be written on foolscap paper, on one side only of each page, leaving a clear margin on the left side for binding, and they should be written in the third person. The drawings illustrating the communications should be on so large a scale as to be clearly visible to the meeting at the time of reading the communication, or enlarged diagrams should be sent for the illustration of any particular portions.

Fig 1. *Buchet Meter*

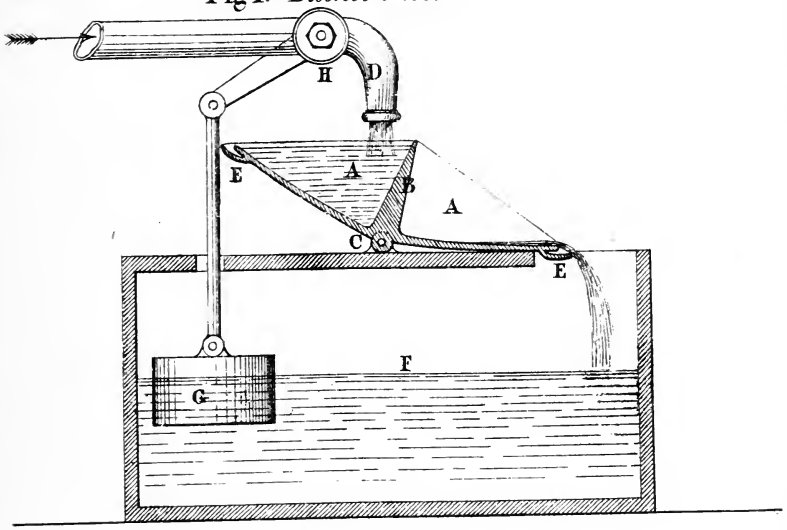
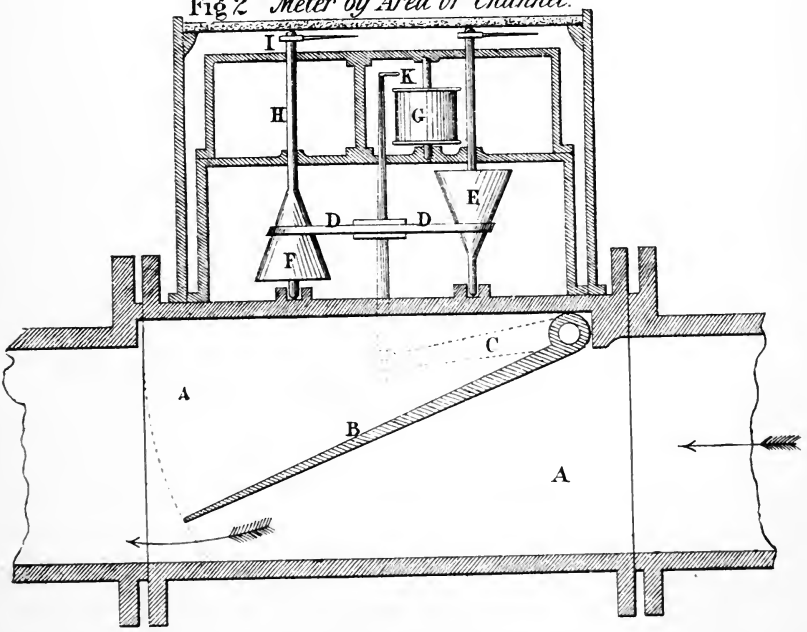


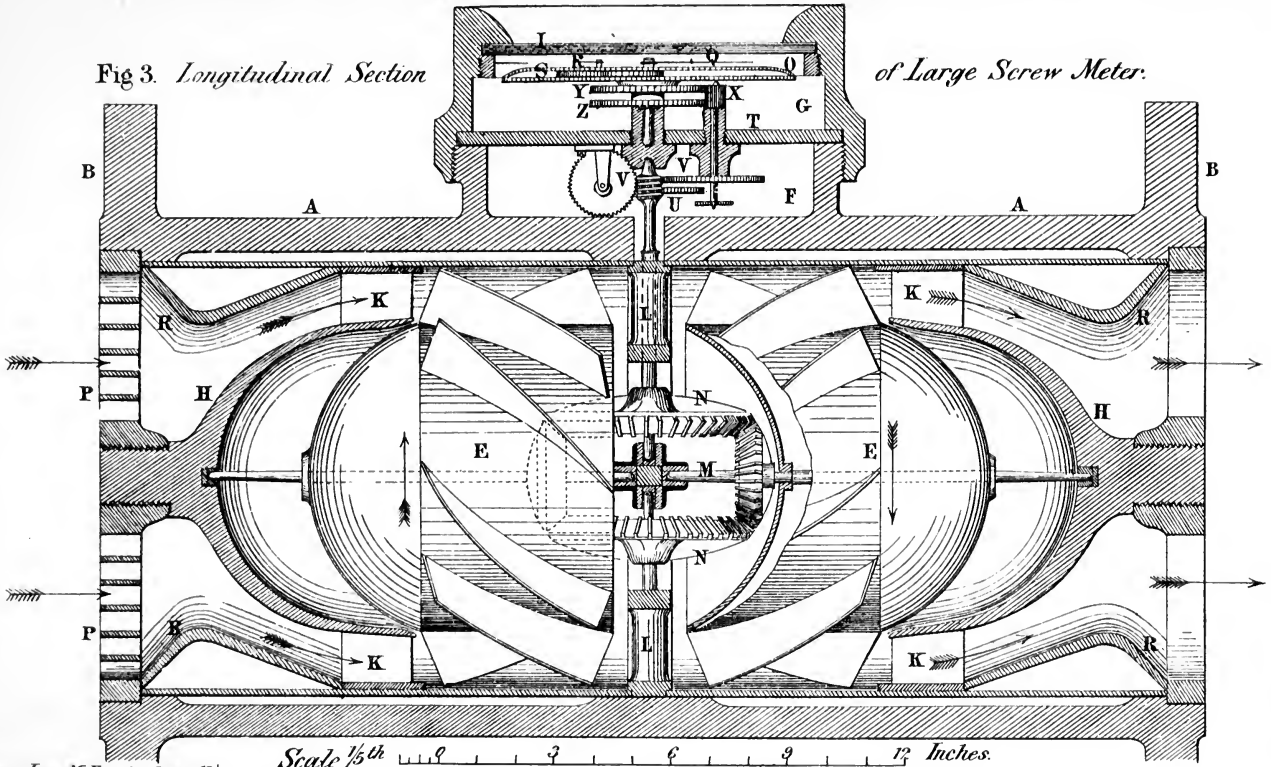
Fig 2 *Meter by Area of Channel.*



(Proceedings Inst. M.E 1851. Page 8.)

IMPROVED WATER METER.

Fig 3. *Longitudinal Section* *of Large Screw Meter.*



(Proceedings Inst M.E. 1854 Page 12)

Plate 2.

IMPROVED WATER METER.

Fig 4. *Transverse Section of Large Screw Meter*

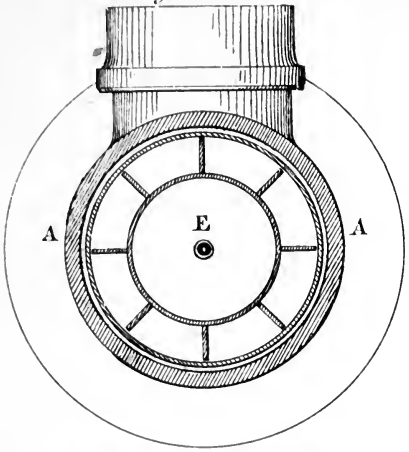
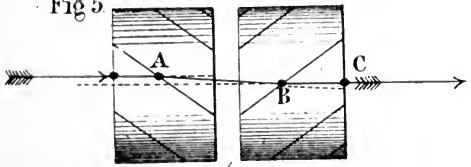
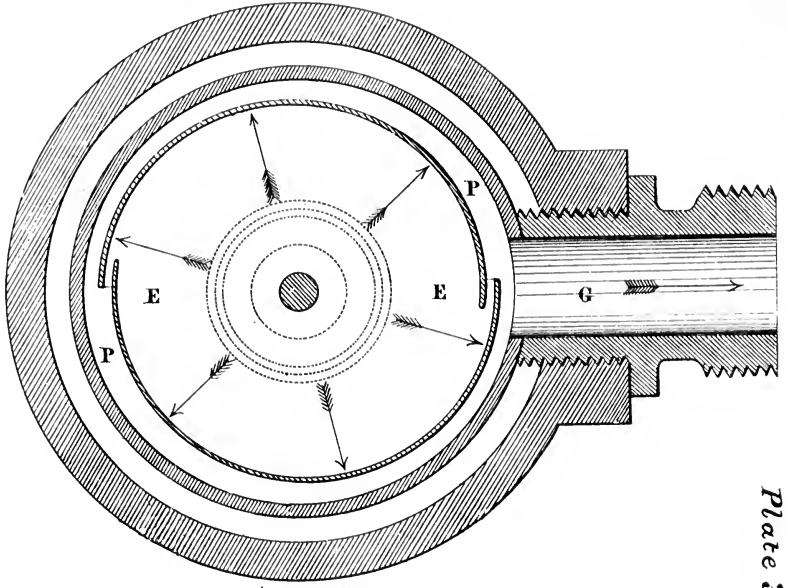


Fig 5



Scale 1/10th size.

Fig. 6.
Plan of Small Spiral Meter.

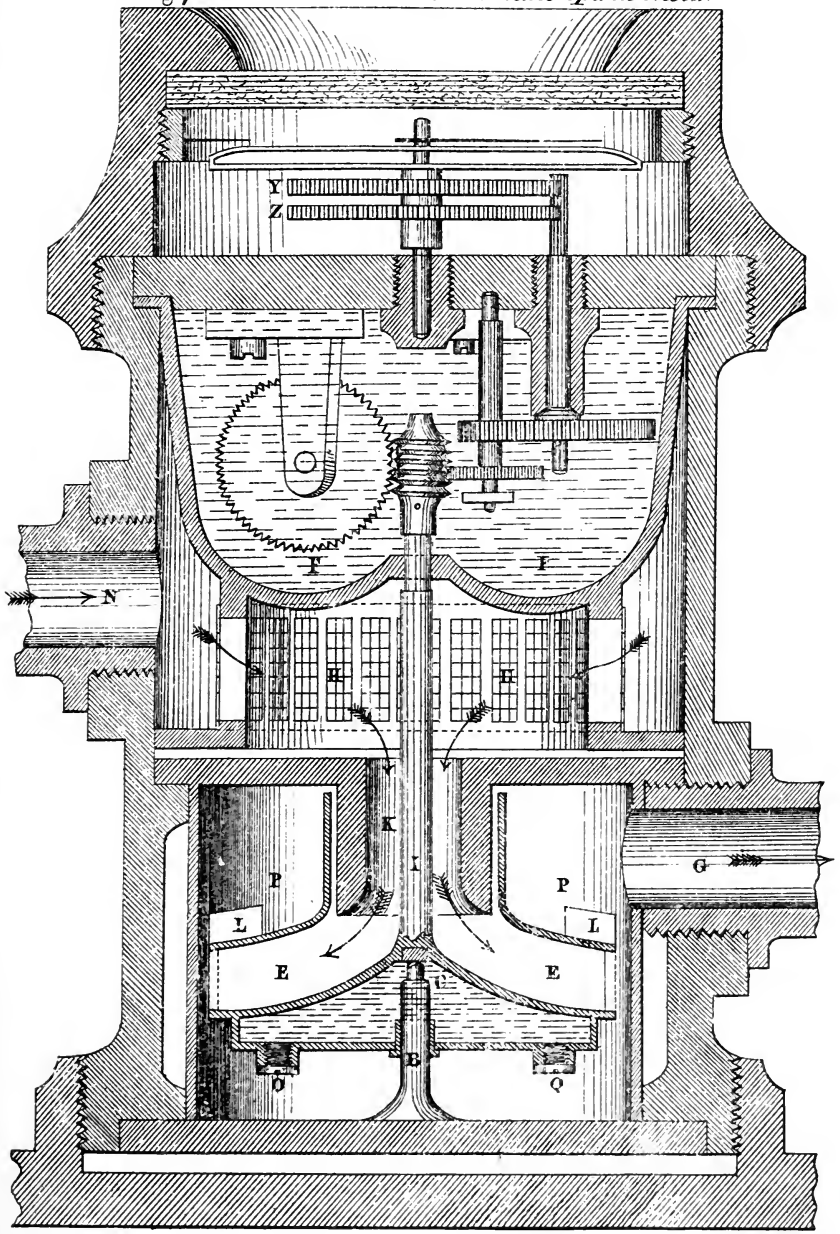


Scale, Full size.

Plate 3.

Proceedings Inst M.E 1854 Page 12.)

Fig 7. *Transverse Section of Small Spiral Meter.*



Scale Full size 0 1 2 3 Inches.

(Proceedings Inst. M.E. 1854 Page 17)

Fig 1. *Longitudinal Section of Fire Boxes*

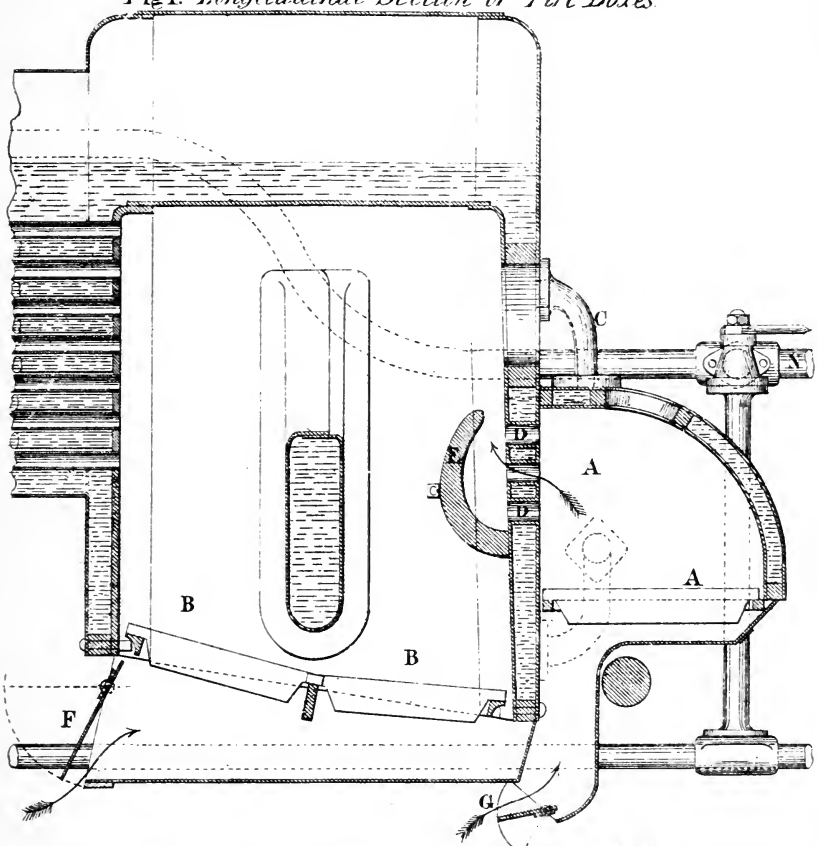
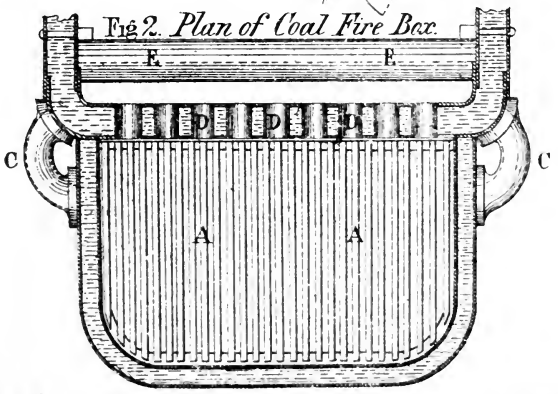


Fig 2. *Plan of Coal Fire Box*

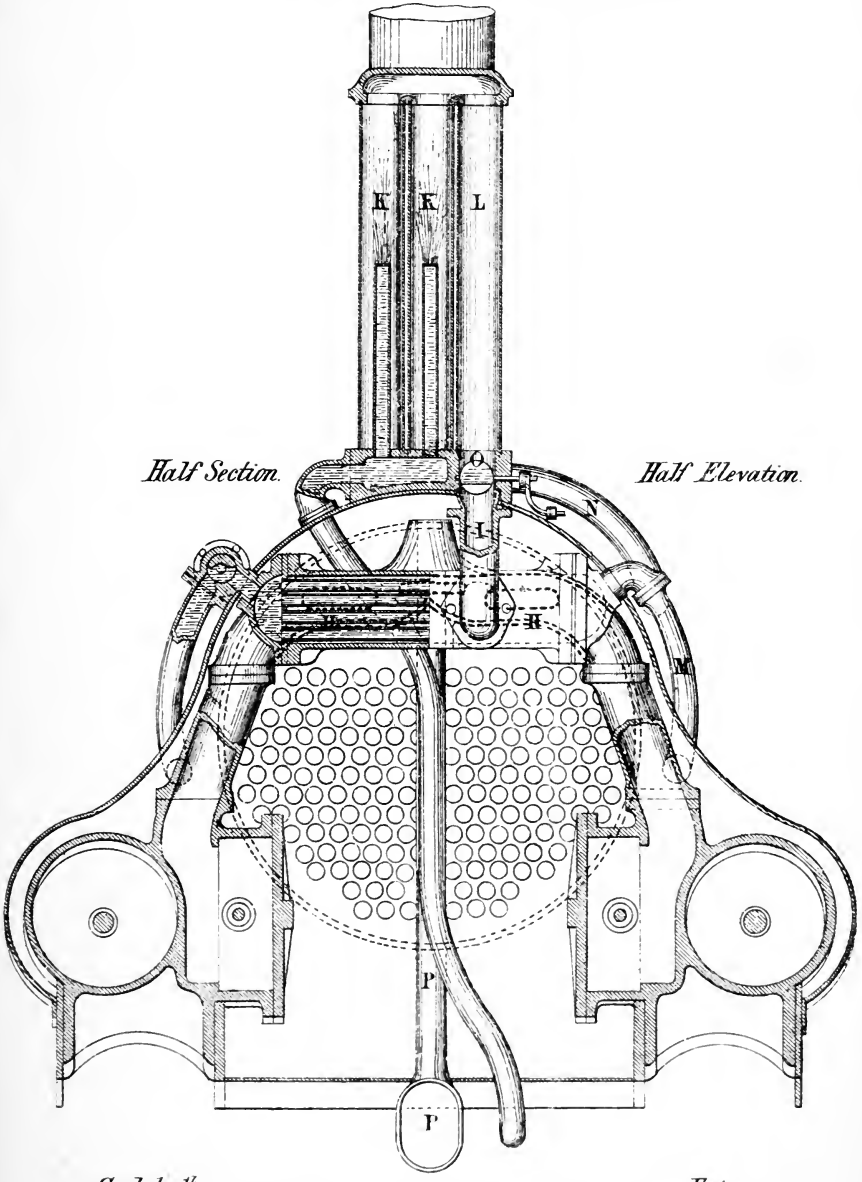


Scale 1/20th 0 1 2 3 Feet

(Proceedings Inst. M.E. 1851 Page 25.)

IMPROVED LOCOMOTIVE ENGINE.

Fig 3 *Transverse Section of Heating Apparatus*



(Proceedings Inst. M.E. 1854 Page 27)

IMPROVED LOCOMOTIVE ENGINE.

Apparatus for Heating the Feed Water.

Fig 4. *Longitudinal Section.*

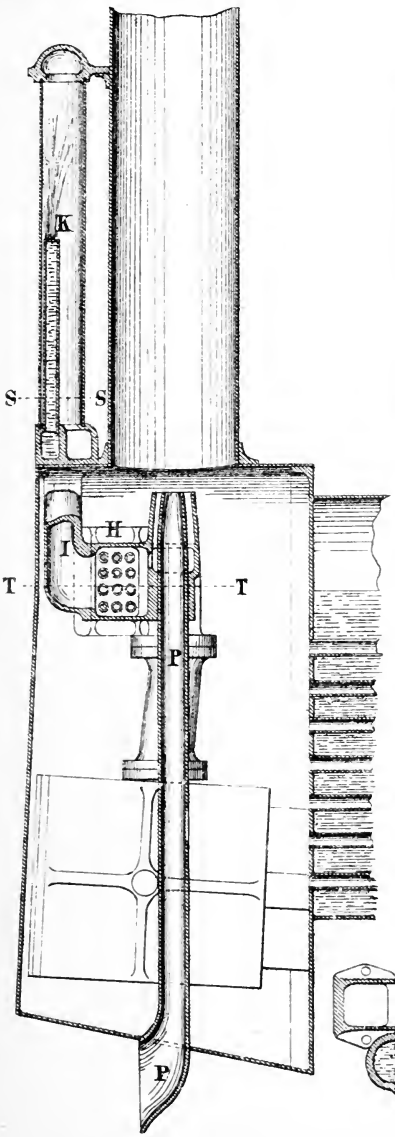


Fig 5. *Side Elevation*

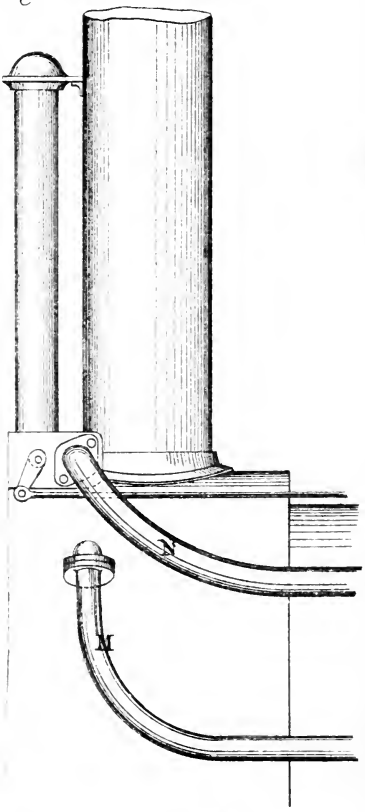


Fig 6 *Plan at* S S

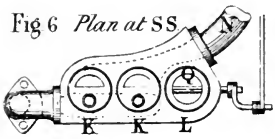
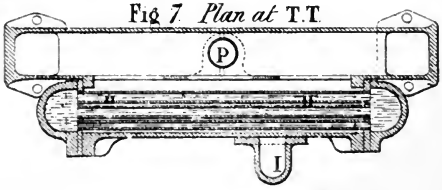


Fig 7 *Plan at* T T

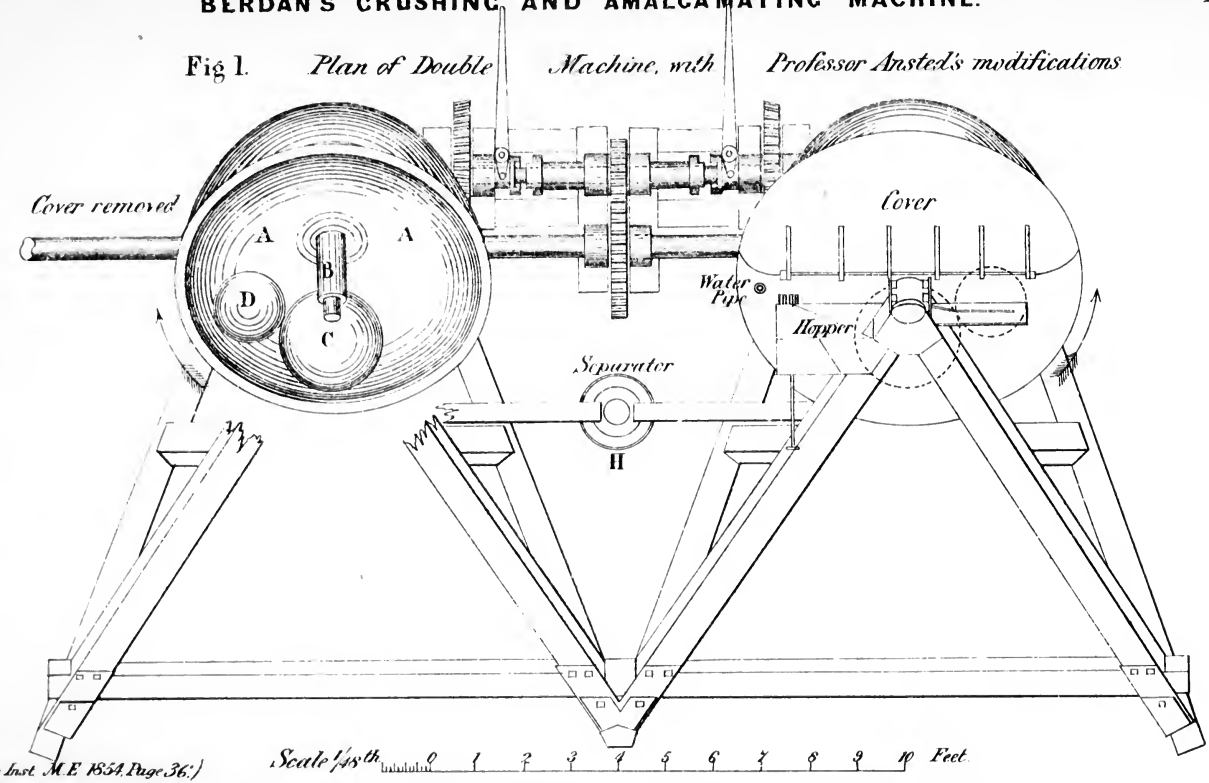


Scale 1/20th 0 1 2 3 Feet

Proceedings Inst. M.E. 1854 Page 27.)

BERDAN'S CRUSHING AND AMALCAMATING MACHINE.

Fig 1. *Plan of Double Machine, with Professor Ansted's modifications*

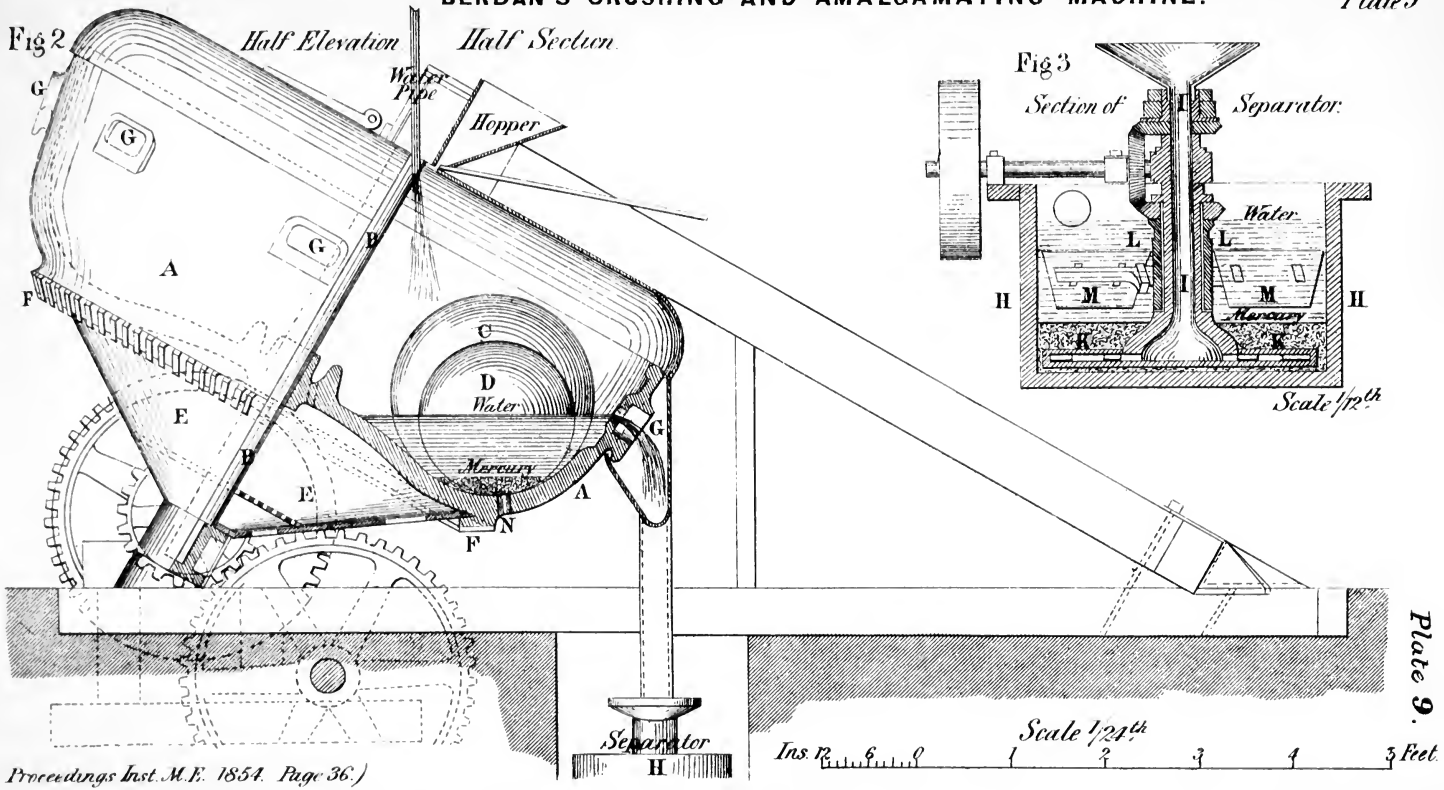


Proceedings Inst. M.E. 1854 Page 36.)

Plate 8.

BERDAN'S CRUSHING AND AMALGAMATING MACHINE.

Plate 9



Proceedings Inst. M.E. 1854. Page 36.)

Plate 9.

RAILWAY TRAIN SIGNAL.

Plate 10.

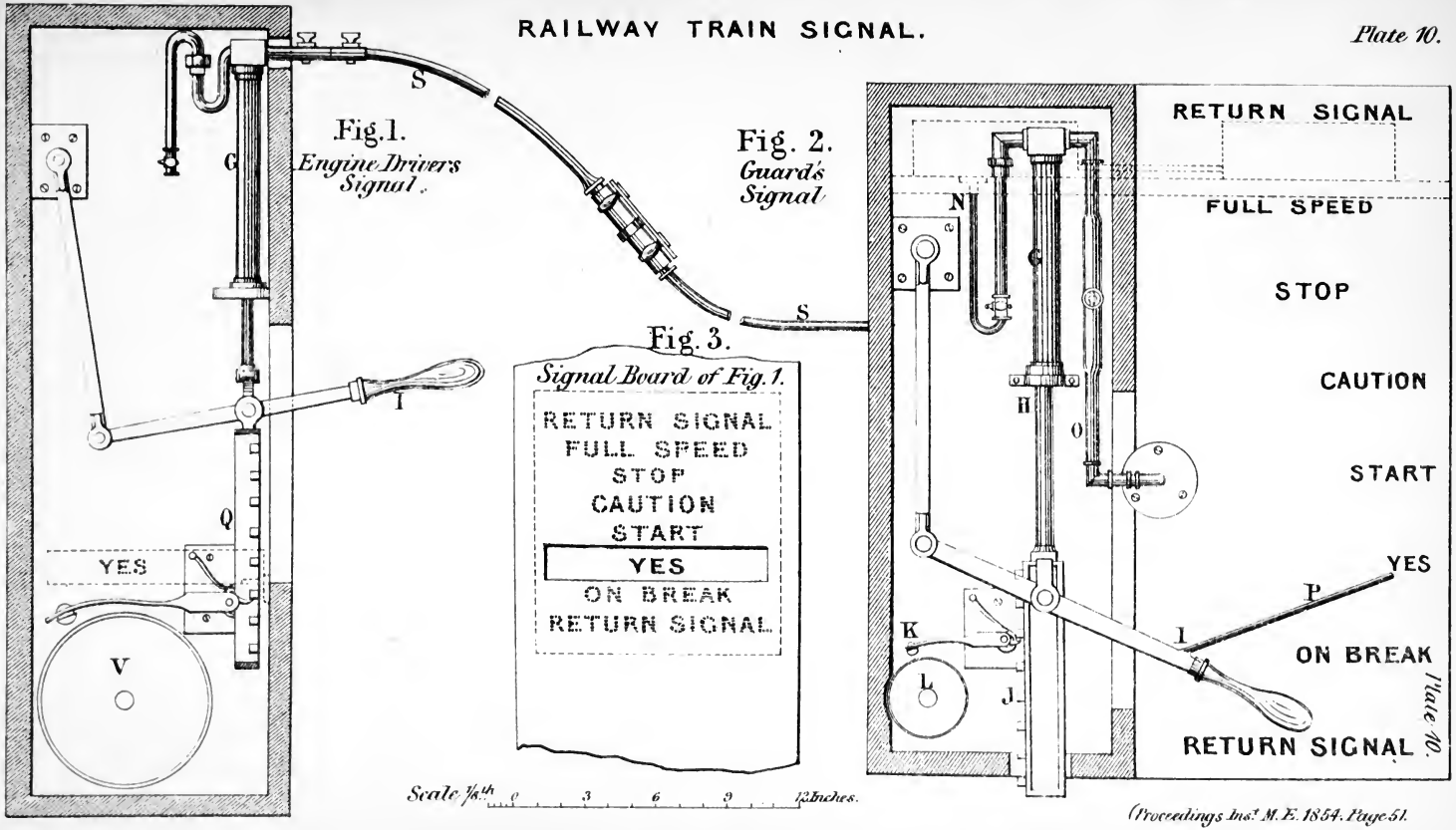


Fig.1. *Engine Drivers Signal.*

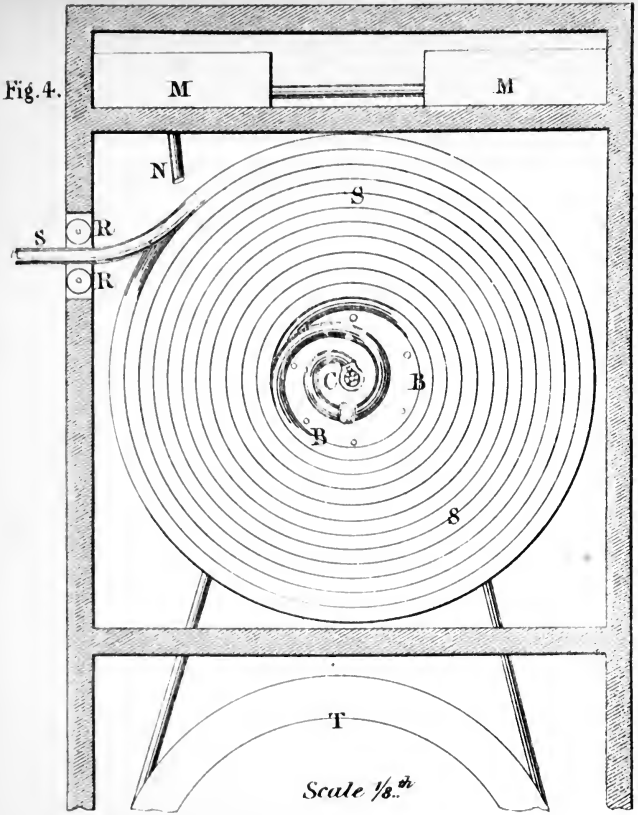
Fig. 2. *Guard's Signal*

Fig. 3. *Signal Board of Fig. 1.*

Plate 10.

(Proceedings Inst. M. E. 1854. Page 51.

Fig. 4.



Scale 1/8th.

Fig. 5. *Coupling Joint of Tubing.*

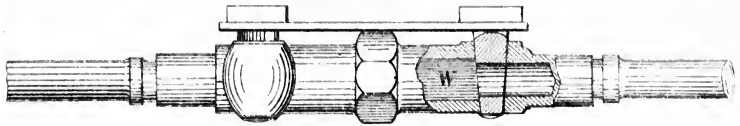
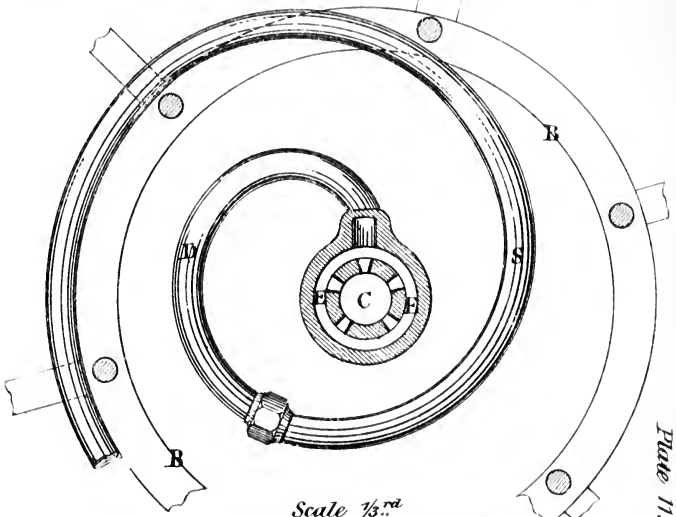


Fig. 6. *Centre Revolving Cock.*



Scale 1/3rd.

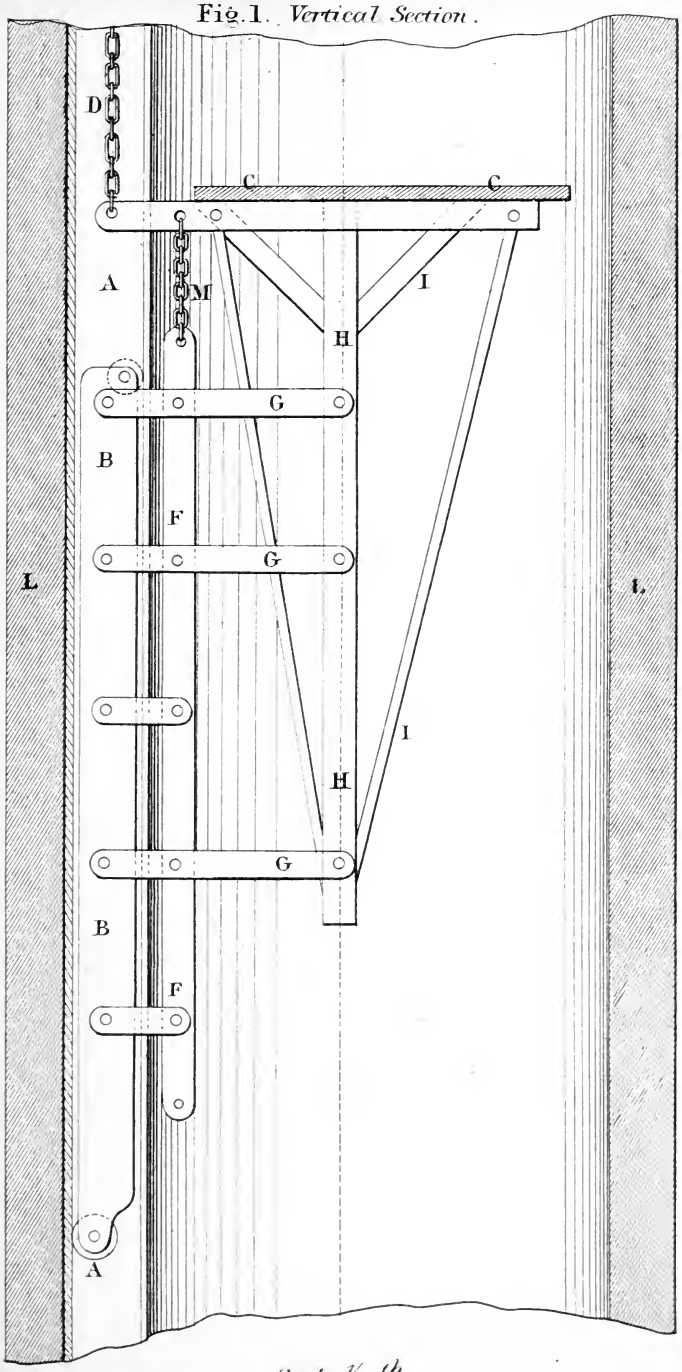
(Proceedings Inst. M.E. 1854.)

Plate II.

SAFETY MINE APARATUS.

Plate 12

Fig. 1. *Vertical Section.*



Scale 1/30th

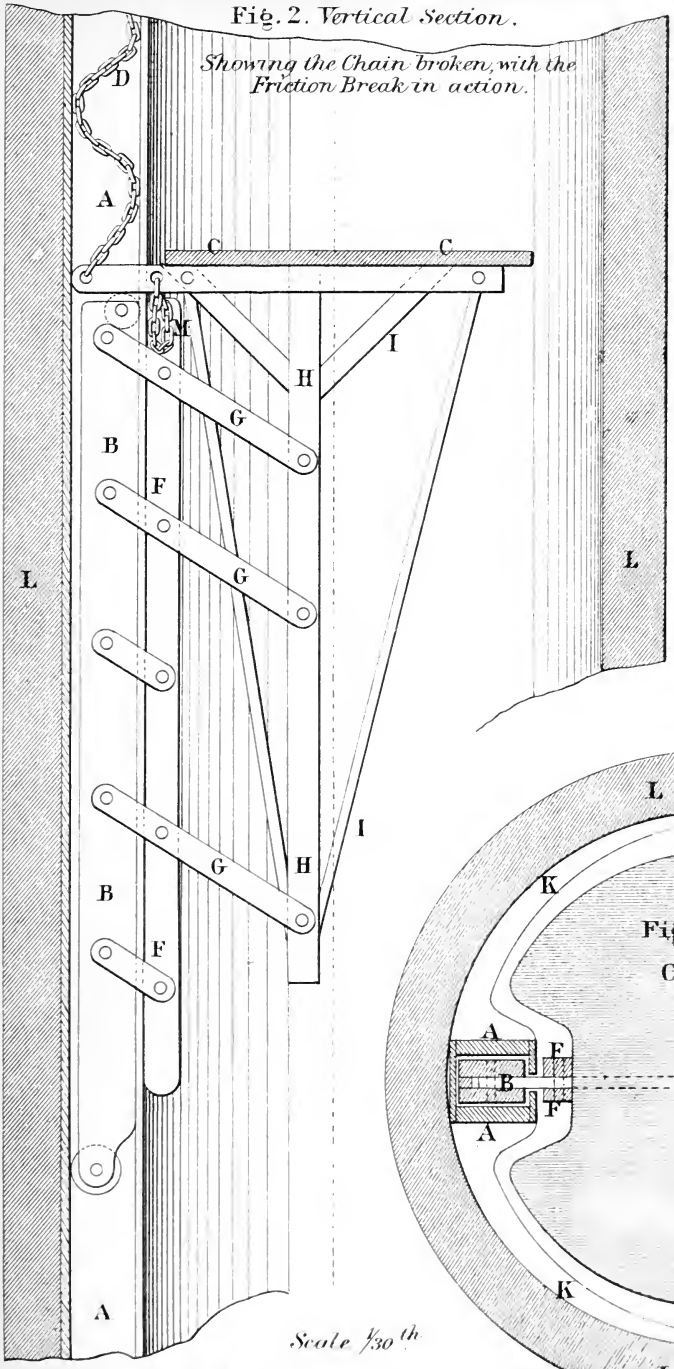
(Proceedings Inst ME 1854 Page 57)

SAFETY MINE APPARATUS.

Plate 1ª.

Fig. 2. *Vertical Section.*

Showing the Chain broken, with the Friction Break in action.



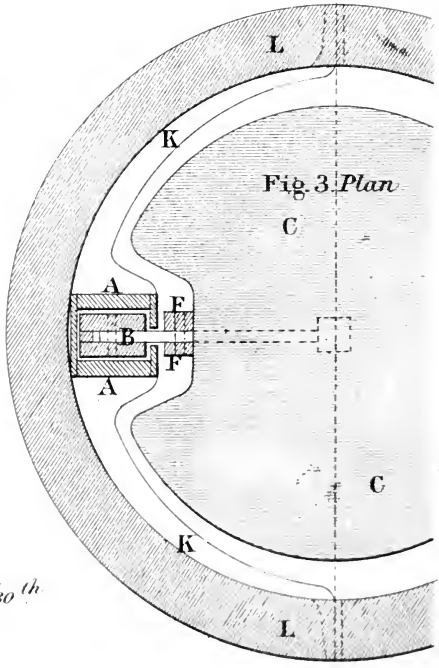


Fig. 3 *Plan*

Scale 1/30th

(Proceedings Inst. ME 1864 Page 57)

IMPROVED CASTING MOULDS. *Plate 14.*

Fig. 1

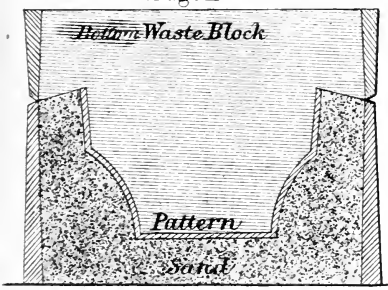


Fig. 2.

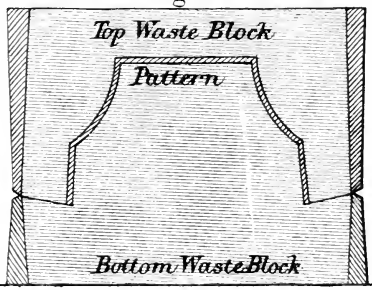


Fig. 3.

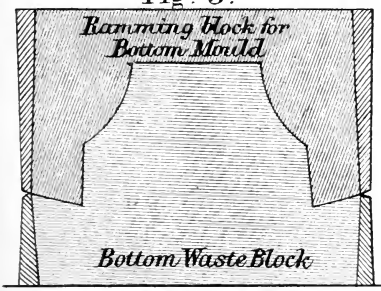


Fig. 4.

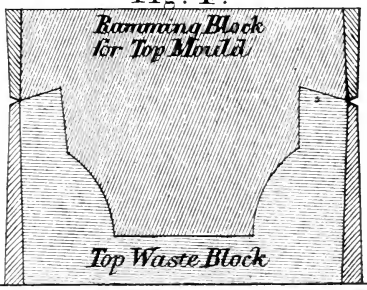


Fig. 5.

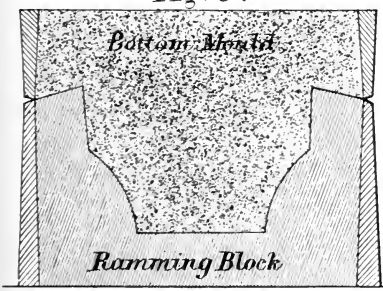


Fig. 6.

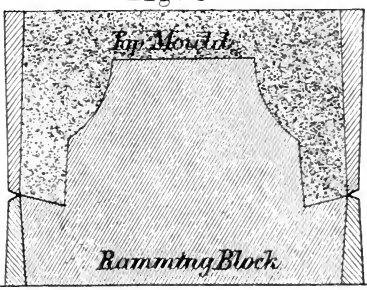
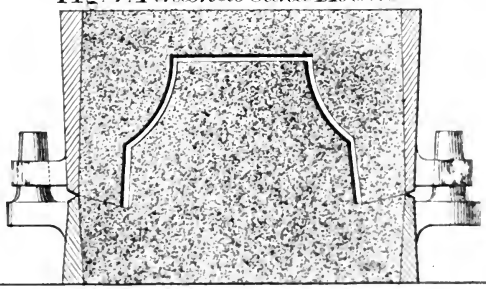


Fig. 7. *Finished Sand Mould*



Scale 1/6th

(Proceedings Inst ME. 1854. Page 63)

Fig. 9. *Ramming block for Top Mould, with pattern secured on face of block.*

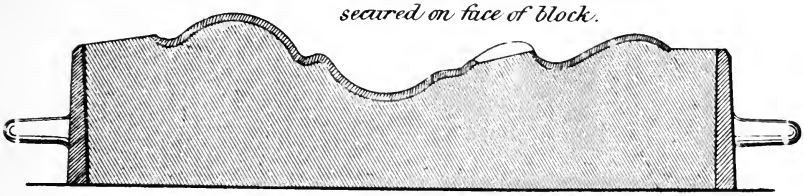


Fig. 8. *Ramming block for Bottom Mould.*

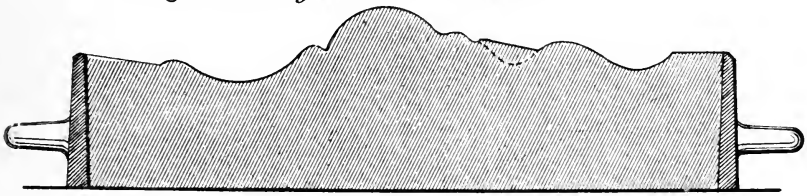


Fig. 10. *Finished Sand Mould.*

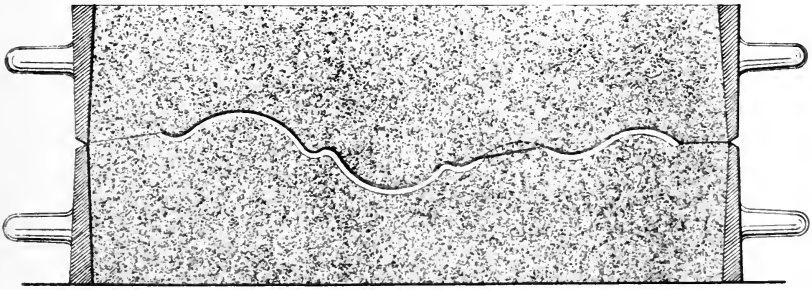
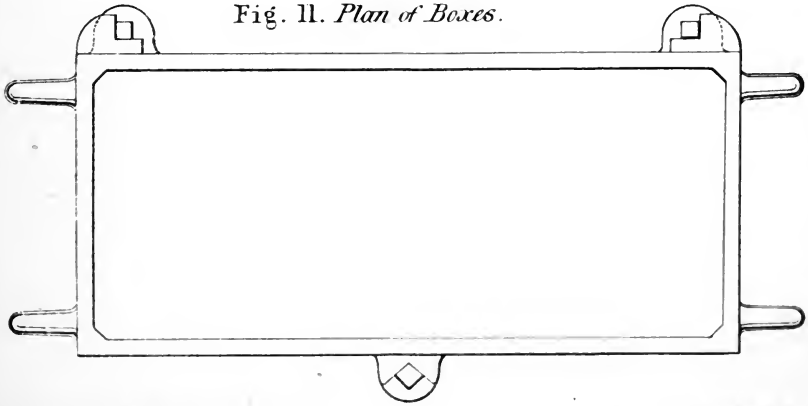


Fig. 11. *Plan of Boxes.*

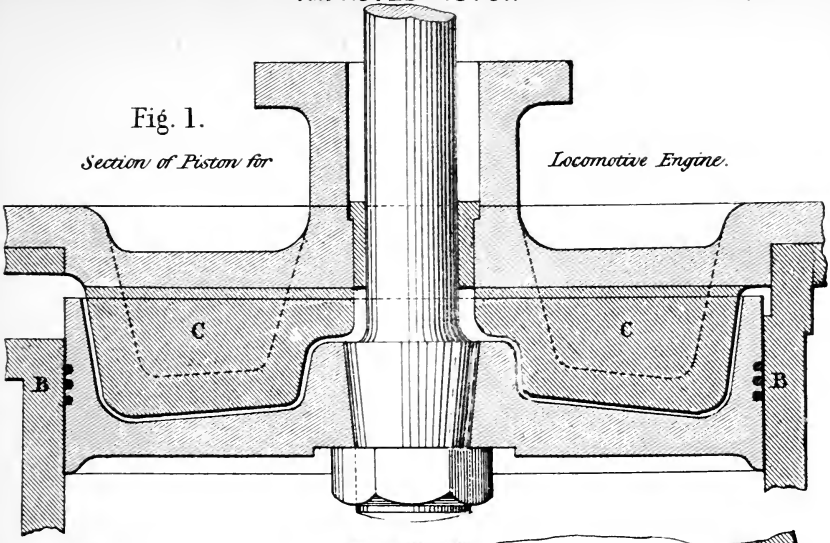


(Proceedings Inst. M.E. 1864 Page 65.)

Scale 1/8th

Fig. 1.

Section of Piston for Locomotive Engine.



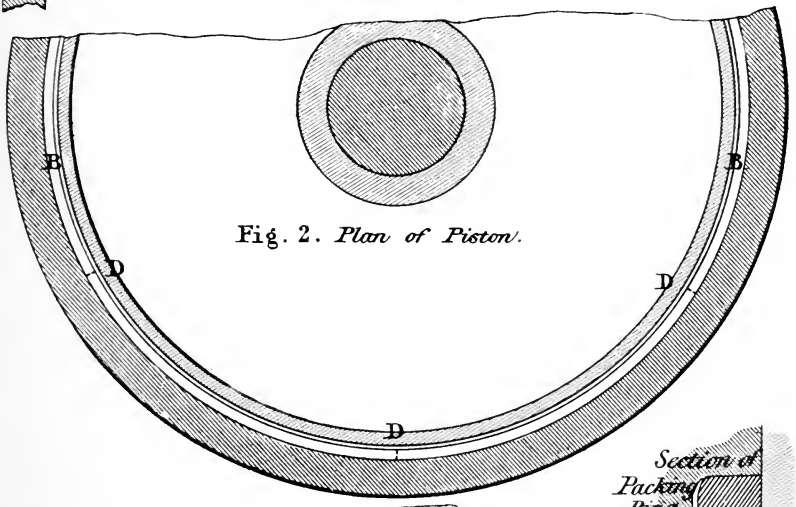


Fig. 2. *Plan of Piston.*

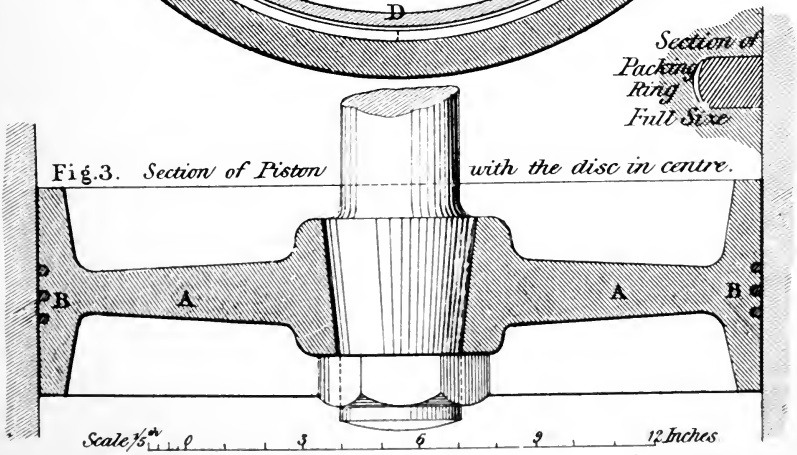
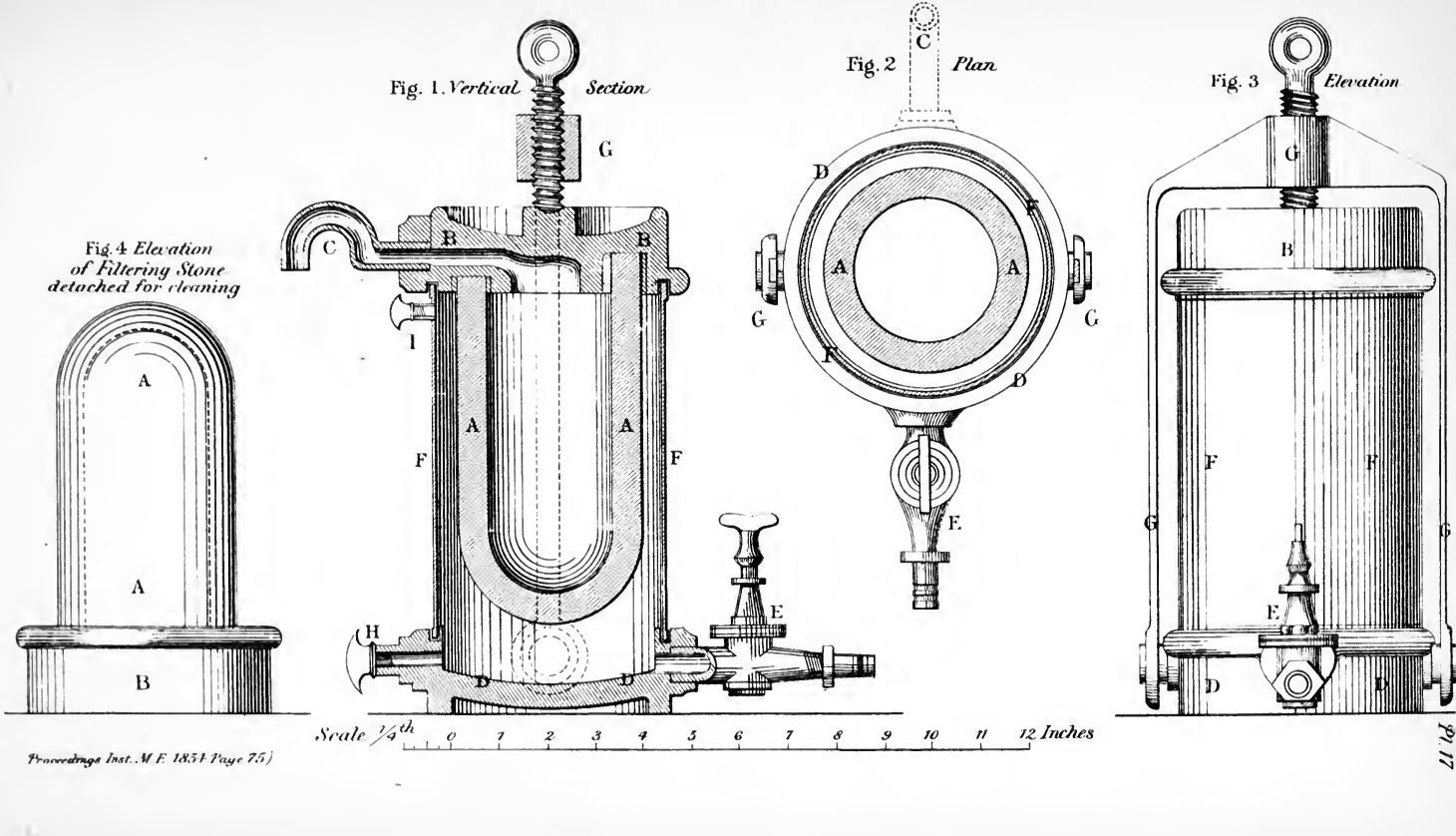


Fig. 3. *Section of Piston with the disc in centre.*

(Proceedings Inst. M.E. 1854, Page 71.)

IMPROVED WATER FILTER.

Plate 17.



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Pl. 17

PROCEEDINGS.

May 3, 1854.

The General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, May 3rd, 1854; Archibald Slate, Esq., Vice-President, in the Chair.

The Minutes of the last General Meeting were read by the Secretary, and were confirmed.

The Chairman announced that the Ballot papers had been opened by the Committee appointed for the purpose, and the following new Members were duly elected:—

Members:

William Bragge, Rio Janeiro.
Thomas W. Dodds, Rotherham.
George Fairbairn, Manchester.
Benjamin W. Goode, Birmingham.
Richard Wm. Johnson, Birmingham.
George B. Smith, Dudley.
Benjamin Williams, Dudley.

Honorary Member:

George Knight, Birmingham.

The following paper, by Mr. Edward J. Payne, of Birmingham, was then read:—

ON A NEW RAILWAY TRAIN SIGNAL.

Numerous have been the attempts and great the skill brought to bear on the subject of providing an efficient means for communicating Signals between the guards and drivers of railway trains, and

still the many and serious accidents constantly arising give warning equally of the vital importance of the subject, and the deficiency of the present contrivances. The numberless appliances that have been suggested, evincing in so many instances the greatest ingenuity and mechanical skill, emanating as they have done from men of acknowledged talent, who have devoted years of toil and thought to that which they and the world know to be of the greatest possible consequence to the community, would appear to be all more or less defective, and have been found liable to fail in the hour of trial.

The principle that appears the most primitive and simplest is perhaps the adoption of a metal rod running the entire length of the train, from the guard's van at the tail to the engine, and coupled between the carriages by link-rods or chains; but the curves of the line and the "buffing" of the train render this impracticable. Remedying these evils, a rope connected with a bell on the engine has been tried ; but here as great a difficulty arises from the amount of slack in the rope, on account of the constantly varying distances between the carriages in a train of ordinary length causing the rope to yield some feet before the tension would become fixed, nor would the guard then feel assured that the signal had been given.

Another mode consisted in applying a flexible tubing the whole length of the train, and terminating in a whistle on the engine, which was sounded and the signal given, by the guard blowing into the mouthpiece at the opposite extremity of the tube. This might answer well enough for a few feet, or even yards, but air being an extremely compressible fluid, no man's lungs could produce a whistle by blowing into any great length of tubing. Electrical agency has been called into requisition, but here several obstacles have also to be encountered; the extreme delicacy of the apparatus, its liability to derangement and consequent interruption of the current, together with the loss of time attendant on the interpretation of the signal, at a crisis when every moment is precious, has rendered the application of this method precarious and uncertain.

But supposing that any or all these methods were found to answer in the duties assigned to them, there still remains one point, of no second rate importance, which by their aid could never be attained. It is this: — that the driver's attention may be called, but he

knows not for what purpose. It may be to stop, something may be wrong in the train, a tyre flown off or an axle broken, or what is just as likely, it may mean "go on," "full speed," or "express coming up behind." Having thus pointed out, briefly, existing defects in railway train signals, the following is a description of the new signal that is the subject of the present paper, in which the object of the inventor has been to remedy if possible the defects in the other plans.

This signal, which is the invention of Mr. Alfred Bird, of Birmingham, works on the principle of hydraulic pressure, the liquid employed being an antifreezing mixture, consisting of alcohol and water. The two cases shown in Plate 10 are placed, the smaller, Fig. 1, on the engine or tender, the larger, Fig. 2, in the guard's van, each being furnished with a signal board containing the same code of signals. The section of the larger instrument, Fig. 4, Plate 11, shows that the interior consists of a drum BB, (shown on an enlarged scale in Fig. 6), mounted on a hollow spindle C, firmly screwed and keyed into the back of the case. The drum BB is furnished with a number of arms connected by slight metal rods; these are for the purpose of maintaining in proper position the flexible tubing SS when coiled, and to guide it in coiling. The tubing SS is of gutta-percha, only 3-8ths of an inch diameter in the bore, but very thick in proportion; and it may be of any necessary length for connecting the two instruments. These instruments (Figs. 1 and 2) consist of similar parts, viz.:—a working pump barrel, GG, connecting tubes, and a lever handle I I. It is essential that both the barrels, the connecting tubes, and the flexible tubing throughout its entire length, should be completely charged with the liquid, and uninterrupted communication obtained, whilst at the same time the drum B is required to revolve on the spindle; this is effected by employing a cock of peculiar construction, shown in section at C in Fig. 6. It is mounted on conical bearings accurately turned on the spindle, fitting precisely similar parts on the cock; the spindle has five and the cock two escape holes, and the groove EE in the cock surrounding the apertures in the spindle, and being constantly full of liquid, maintains uninterrupted communication in whatever posi-

tion the drum may rest. A short length of metal tubing D connects the cock and the flexible tube SS, and prevents any stricture in the latter, which might arise from too sudden coiling round the drum.

On the face of the spindle is the brass cap plate F, Fig. 2, and screwed on to the spindle is an elbow connected to the pipe O, which joins the barrel G in which the piston H is worked by means of the lever handle I. The rack J, attached to the piston H at its junction with the lever, works parallel to and simultaneously with the piston. On the rack are a series of catches corresponding with the number of the signals; these catches (on the passage of the rack downwards) act on a hammer K, causing it to strike the gong L.

The index P on the lever, points to the signal intended to be communicated. MM in Fig. 4, are two reservoirs of the liquid, one of which is connected with the barrel G by the supply-pipe N in Fig. 2, which is provided with a stop-cock for the purpose of regulating the admission of liquid. RR (Fig. 4) are two friction rollers, preventing any abrasion of the tubing during its passage into or out of the case. By the wheel T, banded to the drum B, the tubing may be coiled or uncoiled at pleasure. The smaller instrument intended for the driver, shown in Fig 1, has the parts nearly all of them duplicates of those described; the rack QQ being differently placed to admit of the signal board (shown in Fig. 3) being screwed to the front of it without impeding the operation of the hammer and large gong V, and the handle I passing through the side of the case.

The instrument now exhibited contains a length of 450 feet of tubing coiled on the drum, and it is worked in the following manner :—If the guard requires to signal the driver to "stop," he raises the lever until the index points to that word; the liquid is forced along the tubing and depresses the piston in the opposite instrument, forcing down with it the rack and signal board; the gong is struck, and the word "stop" appears in the slot in the front of the box. The driver then shuts off the steam, and raises his lever until the word "Yes" appears in the slot, thus returning the signal to the guard; should he fail to do so, the guard again signals him "Return Signal." To take another case :—The driver sees a train in advance of him; he shuts off steam and signals the guard

"On Break;" the guard, even if he be asleep, must hear the gong he puts on the break and returns the signal "Yes."

The severance of a train by the breaking of a coupling is no uncommon accident, and it is intended to make this apparatus self-indicating immediately a separation has taken place. The driver, although unconscious, probably runs on with the fore part of the train, the remaining carriages following for a time by their own momentum. Should this arise, the sudden uncoiling of the remainder of the tubing gives timely notice of the disaster, for in connection with the drum is another bell and catch, which is violently sounded by the rapid revolution of the drum, and apprises the guard of the occurrence; and he, although the driver may be one hundred yards ahead, can immediately signal him to "Stop."

It now only remains to describe the contrivance for connecting and disuniting any number of lengths of the flexible tubing, which may be requisite in adding to or taking from the number of carriages in a train. The coupling, shown enlarged in Fig. 5, shows a pair of common gas-cocks with union screw; but it is evident that there will be a space between the stop and the mouth of each cock, which, when connected, would be filled by some of the liquid that would escape immediately the coupling was separated. To obviate this, that space, marked W, is rammed tight with a porous metallic stuffing, consisting of wire gauze rolled up closely and forced in; this affords a medium through which the liquid may be forced, but it is prevented by capillary attraction from escaping without pressure, consequently not one drop will be lost while the coupling is open; and to insure that the coupling be not disconnected until the stop-cocks have been turned off, a plate of metal is secured to them, having slots cut through it, passing over the thumb-pieces only when they are at right angles with the tube, when the communication is shut off, affording a species of lock, and guarding against inadvertence of the person having charge of the signals.

It is proposed to place the tubing either on the roofs or under the steps of the carriages; and probably in some cases it would be preferable to run it along that side of a train on which the doors are locked.

Mr. Bird showed the apparatus in action, the signals being sent through a coil of tubing 150 yards long, extending round the room from one instrument to the other; the mode of coupling the portions of tube was also shown as constructed to prevent loss of the liquid or entrance of air when the joints were uncoupled.

The Chairman inquired what amount of air in the connecting tube was found to interfere with the efficient transmission of the signals? He considered there would unavoidably be always some air in the tube, but it might not be sufficient to interfere seriously with the action of the apparatus.

Mr. Bird said he had tried the experiment with as much as 30 feet length of air in the tube, but found that quantity did not interfere materially or appreciably with the certainty of transmission of the signals, in the 150 yards length of tube that was shown. The air was under very considerable compression, which reduced the extent of its elastic action; a strong spring was made use of to give the blow on the bell, causing a pressure of 42 lbs. on the handle, which was lifted by the pressure of the liquid forced through the tube.

In first filling the tube, the air was all discharged by about 40 strokes of the handle, as shown by the liquid appearing at the other end of the tube; so that if an accidental injury to the tube were to occur, causing half the liquid to be emptied out or the tube to be cut through, the material of the tube (gutta-percha) could be readily joined again, and the tube would be quickly refilled by a few strokes of the pump, and be then ready for work again.

The Chairman inquired what trials had been made of the apparatus, in actual work in a railway train in motion?

Mr. Bird said a complete trial of it had been made on the previous day with two trains of about 14 carriages from Birmingham to Wolverhampton and back (a total distance of 50 miles); and the result of the trial was entirely satisfactory. The different signals were communicated instantly and without any difficulty from the guard to the driver and back again, at any speed and under all circumstances, and no imperfection or error was found in the transmission of the signals. The simplicity and convenience of application of the apparatus was shown by the tube not being connected

until after the train had started, when it was drawn off the drum in the guard's van, carried over the tops of the carriages and connected to the signal-box on the tender whilst the train was travelling, and the apparatus was found at once capable of transmitting signals.

Mr. Maher said he had witnessed the trial of the apparatus, and had travelled with the train throughout the trip; and he was much struck with the promptness and certainty with which the signals were given between the guard and driver in all cases; the apparatus proved quite successful.

Mr. Woodhouse remarked that a great length of train would cause a difficulty in the employment of the tube; the number of couplings required in the whole length to prevent delay in adding or detaching carriages in different parts of the train as might be requisite, would add to the risk of a coupling being left open; and this would cut off the communication of signals, and cause part of the liquid to be pressed out of the tube, requiring fresh adjustment of the apparatus before it could be used to send signals again.

Mr. Bird showed the construction of a coupling in the tube, and the short time required to uncouple the tube and connect it again. He said that although the possibility of a coupling being left unfastened could not be prevented except by careful inspection, the additional time and trouble required for the purpose was very inconsiderable, and he thought the clip shutting down over the coupling would be found a sufficient guard against either of the cocks being left open, as it could not be lifted off to get at the coupling screw without first shutting both the cocks.

The Chairman inquired what was the relative size of the pump and the tube?

Mr. Bird replied that the tube was 3-8ths inch bore, and the pump barrel 1 inch, (about 7 times the area); but he proposed trying the next apparatus with a pump of the same diameter as the tube, which he expected would be preferable in working.

The Chairman thought it more probable that the greater area of the pump over the tube was requisite for the efficient communication of the motion through the whole length of the tube, by producing a sufficiently sudden impulse or concussion, and the requisite degree of compression on the air mixed with the liquid in the tube. There

would, unavoidably, be always a portion of air in the tube, as was found to be the case in water-mains, but this would not prevent a concussion being transmitted through the tube. It was found when too great a quantity of air was left in water-mains that the concussion of each stroke of the pumping engine was transmitted to a very long distance, even as far as five miles, causing the bursting of the mains. The pressure of air in the mains often caused very serious difficulties, and it could not be entirely got rid of, sometimes, from a pipe, even after running a continued stream of water through it for several weeks.

Mr. JOBSON remarked that the same difficulty was often felt with filters; the stream of water was not sufficient to take all the air out of the pipe.

Mr. CLIFT said the presence of air in the tube appeared to affect the action of the signal apparatus, as there was a perceptible interval, though small, between the stroke of the handle and the blow being given on the bell at the other end, showing some elasticity in the communicating medium, though that might be partly attributable to elasticity of the tube.

Mr. BIRD remarked that some time was lost in the falling of the hammer after the catch was released, before the blow was struck.

Mr. JOBSON observed there was certainly a little loss of time in the fall of hammer, but the elasticity was shown in the motion of the second handle at the other end of the tube being a little later than the first handle, both in its starting and stopping.

Mr. W. MATHEWS thought there might be a difficulty in the practical application of this signal, from its interference with the ordinary signals; the engine-driver might have his attention distracted by having to watch the instrument and read the words of the signal, in addition to looking out constantly for the ordinary signals on the line; the number of different signals shown by the apparatus would also be liable to cause uncertainty or hesitation, where prompt action was so essential.

Mr. BIRD replied that he had at present shown seven signals upon the instrument, but that was only a suggestion, to show its capabilities, and it might be modified to give one or two signals only in addition to the bell, if that were preferred. But his special object

in the apparatus had been to give the means for the guard to send a warning to the engine-driver, in a case of a train running in behind, to push on ahead, as well as a signal to stop in case of any accident in the train, and he thought this was an important desideratum in a railway train signal.

The CHAIRMAN said the apparatus was certainly very ingeniously contrived for the purpose, and the motion was conveyed through it with great promptness and certainty; if it proved sufficiently convenient and applicable in the practical working of trains, it would be a very complete mode of communication between the guard and driver. He hoped that the result of more extensive practical trials of the apparatus would be communicated on a future occasion, and he suggested that the trial be first made with one simple signal, not to complicate the experiment with the introduction of a new set of signals, and to avoid any risk of inconvenience from interference with the ordinary signals. He proposed a vote of thanks to Mr. Bird and Mr. Payne, the author of the paper, which was passed.

The following paper, by Mr. Archibald Slate, of Dudley, was then read.

ON A SAFETY APPARATUS FOR WORKING MINE SHAFTS.

The Safety Apparatus described in the present paper is the invention of Mr. William England, of Dudley, his attention having been directed for a long time to the insecurity of the ordinary mode of raising men engaged in mining operations, from several serious and fatal accidents caused by the breaking of machinery and running of the chains and ropes. This is a calamity to which the miner is exposed, and for the prevention of which no effectual mode has hitherto been successfully adopted, the machinery suggested for that purpose being either so cumbrous or complex as to offer serious impediments to its practical utility, did not the expense present an insuperable barrier to its general adoption.

The present invention is intended to supply perfect safety in all cases of ascending and descending, by simple and economical means, as shown in Plates 12 and 13.

Fig. 1 shows a vertical section of the apparatus in its ordinary position when ascending or descending the shaft; Fig. 2 shows the position when stopped by the action of the friction break in the case of the breakage of the chain, and Fig. 3 is a plan of the platform, &c.

AA is a square tube running all down the shaft, and formed of two peices of deal or other wood for the sides, 3 in. thick by 10 in. wide, united at the back by a piece of wrought iron, or hard wood, or a combination of both, one foot in width, strongly bolted to the side pieces; on the front of each of the side pieces is fixed by screws a strip of wrought-iron $5\frac{1}{4}$ in. wide, $\frac{3}{4}$ in. thick, leaving an opening in the centre, $1\frac{1}{2}$ in. wide, the entire length of the tube.

BB is the piston, formed of two pieces of hard wood, with a space left in the centre to receive the parallel motion bars connected with the outer frame or bracket.

C, the stage or moving platform.

D, the chain inside the tube, attached to an iron arm fixed to the platform.

FF are two friction bars of wood, outside the square tube, one on each side, 9 in. wide and 3 in. thick.

GG are parallel motion bars and joints to connect the piston B with the friction bars FF, and carried on to HH, the centre support for the platform, which is stayed by diagonal struts II.

KK are cast-iron half ring stays to support the tube, which is made in lengths of 20 to 25 feet; the end of this ring towards the tube is T shaped, forming a support for the foot of each length, a broad flange securing them by screws at the side; the ends of these stays are wedged into the brickwork of the shaft LL.

Fig. 1 shows the stage being lifted by the chain, which is prevented being drawn beyond the horizontal line by a stop chain M, or other means, causing the bracket and piston to rise at the same time with any load placed upon the platform.

Fig. 2 shows the stage with the chain broken and stopped in its descent by the friction between the front plate of the tube and the piston B and friction bars FF.

The effect of the snapping of the chain is to bring the bracket and piston together, the quickness of the action and amount of friction being

determined by the weight raised; and it is an important advantage that the chain cannot descend into the pit, but it is always retained in the tube, thus obviating the necessity of bonnets and strong unwieldy cages for the protection of the men. At the same time lighter chains may be advantageously substituted; which circumstance, from these chains being retained in a uniform position whilst at work in the tube, and not being subjected to the rotary and twisting movements by which they are now tried, must tend considerably to their preservation.

For shafts out of the perpendicular, where ordinary guides cannot be used, this invention is well adapted, the tube being sufficient to insure steady working; and where applied it must effectually prevent the loss at present arising from the quantity of coal broken by oscillation and contact with the sides of the shafts.

It will be observed that the most perfect security is here afforded the men in going to and returning from their work, whilst the apparatus presents additional facilities for ascending and descending; men and materials can even be raised and lowered at the same time. The construction is simple, every part being composed of inexpensive materials, not liable to derangement, and requiring no further overlooking or attention than can be given by the ordinary engineer; and when the apparatus has performed its duty in one pit, it can be easily removed to another.

The weight of the stage, bracket, and piston is estimated by the inventor at about 7 cwt., and the cost of applying it at not more than 15s. per yard, and the annual expense of working at less than five per cent. upon the outlay; and that when the saving effected in the repairing of the shaft and the loss from slack made by the present mode of raising is duly estimated, considerable deductions have to be made upon these calculations; but whatever be the pecuniary advantages arising therefrom, the main object of the invention is the security of the miner in his hazardous employment.

Mr. England exhibited a working model of the apparatus, and showed its action. He observed that the construction proposed for the apparatus was very simple, with no expensive materials or work-

manship, and it had been a particular object to keep it free from any objection of complication or difficulty of repair. The pitman could easily do the repairs that might be required, and all the material made use of was ordinary bar iron and timber, all of which would come in for other purposes.

The CHAIRMAN observed that there had been many ingenious plans invented for the purpose of increasing the safety of working pits, but this plan had one advantage over others, which appeared deserving of consideration, in keeping hold of the chain during the whole descent, to secure it from falling into the pit in case of breaking. In the ordinary plan there was more risk of accident to the men, perhaps, from the chain breaking and falling on their heads when near the bottom of the pit, than from the actual falling of the men, although strong bonnets were employed to shelter them; but in the proposed plan the chain was guided in a tube or channel all the way down, and this might have the advantage of allowing some reduction in the weight of the chain, from the strain being diminished by preventing it from swaying about.

Mr. R. WILLIAMS inquired how it was intended to prevent particles of the coal slack getting into the groove? He thought there was a risk of the piston getting jammed in drawing up, from an accumulation of dirt and grit in the groove.

Mr. ENGLAND said he proposed to cover up the front of the groove by an iron plate sliding with the platform, and long enough to prevent anything from falling into the groove. He did not see that any difficulty was to be anticipated from obstruction in the groove, as the passage of the piston through it each time would keep the whole clear, and it was intended the piston should fit quite loosely, so as not to leave any liability to get jammed.

Mr. G. THOMSON thought that the constant friction of the piston against the side of the tube would be very serious, from the overhanging weight of the platform, and would cause great wear, as well as a liability to interfere with the regular working of the platform. The platform and piston acted as a bent lever, the point of suspension being the fulcrum, and a portion of the weight of the apparatus and the load, in proportion to the leverage, would therefore act as a constant pressure upon the side of the piston through

the whole time of ascending and descending, and with a heavy load on the platform the friction might actually stop it in descending.

Mr. ENGLAND said that a friction-roller was fixed at the bottom end of the piston, to roll up and down against the back of the tube, where the whole pressure would take place, and to prevent the piston from rubbing against the tube. The length of the piston was intended to be considerably greater than the projection of the platform, to diminish the leverage at which the weight acted, and reduce the pressure on the friction roller accordingly. A second roller might also be fixed on the front of the piston at top, if considered desirable.

Mr. THOMSON remarked, that friction-rollers were liable to stick fast, and there would be much difficulty in keeping a roller in working order in such a situation; and he thought it possible that the pressure might be so great from a heavy load on the platform as to prevent the roller from turning, and that the friction would be liable to stop the descent of the platform when not desired: but under any circumstances the roller only mitigated, and could not remove the objection. He did not consider that a provision was required for guiding the rope in case of breaking, as the cases of accidents from breakage of the rope were very few, in his experience, and the ordinary plan of an iron bonnet over the platform he thought was a sufficient protection for the men. He preferred a light wire rope to a chain, and this in case of breaking did not fall with force enough to injure a tolerably strong bonnet; the wire rope in falling, he had observed, did not fall straight down like a chain, but took a cork-screw form round the shaft.

Mr. MATHEWS was also of opinion that the proportion of accidents arising from breakage of the ropes was very small; amongst 20 to 30 pits that he had had at work for some years, he could only recollect one accident of men being precipitated down the pit, and in that case it was not really the rope that broke, but it became detached from the drum. The strain on the rope was considerably less when the men were going up and down than in the regular work of drawing coal, as the load with the men was only one half or one-third, about 12 or 14 cwt. compared to 25 or 35 cwt. Any mode of diminishing the risk of accident to the men deserved the best attention; and trouble or expense

should not be a consideration if a decided increase of safety would be insured; but in this present case the risk of accident from breakage of the rope was really very small, and there was generally a pretty effective control to prevent accidents from defect in any part of the apparatus. He thought the introduction of a new principle in the apparatus would be difficult to effect, and there would be a reluctance to adopt it, when there were so very few chances of its particular advantages being made available.

The CHAIRMAN observed, that as a general principle self-acting machinery was certainly not advisable, because it induced less carefulness on the part of the men; they were apt to rely too much on any self-acting provision against accident, and to relax their vigilance, instead of taking care to prevent its occurrence by removing the cause of danger in time. The present apparatus was ingeniously contrived to meet the case, and its value would of course depend upon its certainty in preventing accidents, as well as the risk of such accidents occurring.

Mr. THOMSON remarked, that unless a machine was really perfect in guarding against accident, as well as very simple, to prevent liability to get out of order, it was better not to depend upon it, and to trust to the care of the men; and then there was the objection to using the machine at all, that it had the effect of inducing less caution on the part of the men. But if a machine could be absolutely depended upon, and were to be the means of preventing even one fatal accident in many years, it would be worth adoption.

The CHAIRMAN then proposed a vote of thanks to Mr. England, which was passed.

The following paper, by Mr. Robert Jobson, of Dudley, was then read:—

ON AN IMPROVED CONSTRUCTION OF MOULDS FOR CASTING METALS.

The subject of this paper is the invention of Mr. John Jobson, of Derby, and may perhaps be considered as one of the results of the difficulty experienced in the labour market. This invention consists of a mode of constructing the moulds for metal castings, by

means of which the process of moulding is rendered simpler and easier; so that an important economy is effected in the cost and time of moulding; also the accuracy and perfection of the moulds is increased, so that the castings produced have less "fin" or other irregularities than usual, and greater uniformity is insured in running the metal than in the ordinary method of moulding, reducing the proportion of "wasters."

The advantages of the new plan are most felt in the cases where a large number of castings have to be made from the same pattern; also where the more intricate form of the pattern (as in foliage or ornamental castings) makes it difficult to draw from the sand in the ordinary process of moulding, and the irregular surface of the "parting" or separation between the moulds increases the difficulty of making a clean casting, free from "fin," and also involving a considerable time and skilful labour, which has to be repeated for every casting.

In the ordinary plan of moulding with "odd-side boxes," the pattern from which the casting is to be made is imbedded partly in the sand of the top box, or in an odd-side board prepared for the purpose, and the bottom box is then placed upon it and rammed full of sand, imbedding the rest of the pattern; the boxes are then turned over, and the "top box" or "odd side" lifted off, leaving the pattern in the sand in the bottom box; "parting sand" is then applied, and another top box rammed upon it, the pattern still remaining between; the boxes are then separated, the odd side is again put on, the bottom box turned over, and the pattern left upon the odd side. After the impression of the pattern in the sand of the two boxes has been completed, by repairing any damage done in removing the pattern, the top box is again placed upon the bottom one in its original position, and the casting made.

In the *new process* of moulding (the subject of the present paper), after the pattern has been first partially imbedded in the sand of the bottom box as in ordinary moulding (see Fig. 1, Plate 14), and the parting surface been accurately formed, the top box is then placed on, and is filled with plaster of Paris, or other similar material, to which the pattern itself adheres. When the plaster is set, the boxes

are turned over, the sand carefully taken out of the bottom box, and a similar process repeated with it (see Fig. 2), using clay wash to prevent the two plaster surfaces from adhering; this forms a corresponding plaster mould of the lower portion of the pattern. These two plaster moulds may be called the "*waste blocks*," as they are not used in producing the moulds for casting, but are subsequently destroyed.

Reversed moulds in plaster (Figs. 3 and 4) are now made from these "waste blocks," Figs. 1 and 2, (the pattern being first removed) by placing upon the bottom box a second top box, an exact duplicate of the former top box, and filling it up with plaster (having used clay wash as before), and doing the same with the other box. Reversed moulds are thus obtained, from which the final sand moulds for casting are made, by using them as "*ramming-blocks*," upon which the sand forming the mould is rammed by placing a third duplicate top box, Fig. 6, upon the ramming-block, Fig. 4, and a corresponding bottom box, Fig. 5, upon the ramming-block, Fig. 3.

The requisite "gits," "runners," and "risers" are formed previously in the original sand mould, and are consequently represented in the ramming-blocks (Figs. 3 and 4) by corresponding projections or ribs upon the parting face of the one, and hollows in the other, (which are then stopped up with plaster,) and these are properly repeated in the final sand moulds, Figs. 5 and 6; these last, therefore, when put together, as in Fig. 7, form a complete mould for casting, just like an ordinary sand mould, but having some important advantages.

Any number of succeeding moulds can be made from the original ramming-blocks by the simple process of ramming, without any handling of the pattern or turning over the boxes, both top and bottom moulds being rammed independently and at the same time if desired. The parting being once accurately formed in the original mould, all the succeeding ones are necessarily correct, without any further care being required; and by carefully trimming the original and slightly paring down the inner edges of the parting faces, if requisite, the faces of the final sand moulds have a corresponding fulness, and are readily adjusted, after the first trial, to fit so closely together, that practically no fin is left on the castings, as shown by the specimens before the meeting, which are all of them just in the

state in which they left the sand, never having been dressed or trimmed. Also the labour of forming the git and runners afresh for each casting mould is avoided, by having them completely imprinted upon each mould in the process of ramming; and by this means all the risk is avoided of imperfect castings arising from want of uniform care or judgment in the formation of the gits, &c., by the moulder in the ordinary process. This is the more important in the case of difficult castings, where several trials may be required before the best mode of running the metal is ascertained so as to insure sound, good castings; and by this process the exact repetition of the same plan is insured, without requiring any further attention from the moulder.

A small hollow is imprinted in the ramming-block for the top box, into which the plug for forming the git is rested whilst the box is rammed, and by this means the git is insured being formed in the right place, without any care on the part of the moulder.

The process of moulding by this plan is so simple and certain that ordinary labourers are quite sufficient to make the best castings, as they have nothing to do but ramming the sand upon the two blocks in each case, forming the back and front of the pattern, and putting them together without having to pay any attention to the parting gits or runners; and also it is much easier to lift the boxes when rammed off from the blocks, than to pick out the pattern from the face of the mould as in the ordinary process; the whole being in one solid mass in the new plan, it can be lifted more steadily, with less risk of injury to the sand mould.

When the pattern is long and very thin and intricate (as in the case of an ornamental fender front) where the general surface is also curved or "winding," as in Plate 15, the difficulty of picking out the pattern from the mould is so great as to require the most skilful workman; and the length of time required for repairing the injuries of the mould, causes about eight sets of fender castings per day to be the general limit to the number that can be moulded by each man and boy. But however difficult the pattern may be to mould in the ordinary way, (if it is arranged to "draw" properly from the mould) with the new process the labour is very little greater than with an easy pattern, and

the saving of time is so great that as many as 30 per day are moulded on the average by one labourer and boy; being four times the number that the best moulder can produce by the ordinary plan.

When the pattern is slender and long it is liable to be broken in the frequent handling to which it is subjected in the ordinary process of moulding, and the expense and delay caused by breakage of patterns is of serious consequence in light ornamental work, where the patterns are often very expensive; but in the new plan this is entirely avoided, as the pattern is never handled at all except in the original process of moulding to form the ramming-blocks.

When the face of the castings is required to be particularly well finished (as in the case of ornamental work) a brass or other metal pattern is made, and is dressed up and finished to the degree that may be desired in the castings, and any chasing or other additional ornament put upon it; then after forming the ramming-block for the bottom box by a plaster cast from the pattern in the manner before described, (see Fig. 8) the pattern itself is made to form the permanent face of the ramming-block for the top box, (as in Fig. 9) by leaving it in the mould when the plaster is poured in, so that the plaster forms merely the parting face, and a solid back to the pattern. In this case, the iron pattern is secured to the cross bars of the box by several small bolts screwed up to plates at the back of the box, so that when the plaster is poured in, filling up the whole vacant space of the box, and setting solid around these bolts and over these nuts, the iron pattern becomes so firmly secured in the box that no ramming or moving it is subjected to afterwards has any risk of loosening it.

In this plan the mould for the face of every casting is formed from the original metal pattern, and the pattern itself is firmly and permanently secured in the plaster bed, so that however thin and delicate it may be, there is no risk of injury to the pattern, in moulding any number of castings; as many as 3,000 have been cast without injury from a slender ornamental pattern.

In forming the ramming-blocks, common plaster of Paris is most generally employed, as the most convenient and economical material, and this is found to be sufficiently durable for general work; the blows of the rammer are deadened by the sand in the box, and do not fall

directly upon the plaster block, so that there is no risk of injury with ordinary care in ramming. As many as 4,000 castings have been moulded from one pair of plaster blocks; but when a greater number of castings are required to be moulded from one pattern, or when the size or nature of the mould renders a harder face advisable, a metal face is employed for the ramming block of the bottom box, or for the parting surface of one or both blocks. This is formed simply by running into the mould when prepared for the plaster, a small portion of metal, consisting of zinc hardened with about 1-15th part of tin; sufficient metal being used to form a strong plate for the surface of the ramming-block, and the rest of the space at the back filled with plaster as usual. In practice it is more convenient generally to reverse the mode of running this metal for the face of the mould, by first ramming the box, when prepared for the plaster, full of sand, then lifting it off, and paring off the surface of the sand wherever the metal is wanted to such depth (about $\frac{3}{8}$ of an inch) as may be desired for the metal, and when the box is replaced in its former position the metal is run in, filling up these spaces where the sand had been cut away. The sand in the upper box at the back of the metal face is then all removed, without moving the box (part at a time if requisite) and plaster poured in above to fill up the box and make a solid back as before.

The metal face is firmly secured to the plaster back by several small dovetail blocks cast upon the back of the metal, by cutting out corresponding holes in the sand mould before the metal is run in. Various modifications of this plan of construction are employed, according to circumstances, for economy or convenience, and sometimes the face of the ramming-block is partially covered by separate pieces of metal; but in every case the entire face of the two ramming-blocks forms a perfect counterpart of the intended casting, (half being represented upon each,) surrounded by parting faces which exactly fit one another, because the one has been moulded from the other.

Where the pattern is long, and a metal face is employed, a narrow division is made, subdividing the metal face into two or more lengths, to allow for the shrinking of the metal forming the face, the effect of which is then found to be imperceptible. The plaster ramming-blocks are varnished when dried, to preserve them from damp; and in moulding from them the faces of the blocks are dusted with rosin, to prevent adhesion of the sand.

The new process of producing the blocks, though somewhat complicated in description, involves practically but little increase of work over the process of moulding required for the first casting produced by the ordinary method; but every subsequent casting, instead of requiring a repetition of the whole process of the first moulding, as in the ordinary method, is moulded by simply ramming the boxes upon their respective blocks. The ordinary "odd-side" boxes are used for this purpose, all that is requisite being that every top box fits steadily and securely upon every bottom box, so that they may be interchanged in the process of forming the ramming-blocks, without disturbance of the relative position of the pattern. An improved form of the steady pins for connecting the top and bottom boxes has been adopted, as shown in the specimens exhibited, which is easier to construct with accuracy. Instead of four or more round pins fixed on the bottom box, and fitting into corresponding holes in lugs cast upon the top box, vertical angular studs are cast on each bottom box, and fit against corresponding projections on the edge of the top box (as shown in the plan, Fig. 11, and the section, Fig. 7); the only fitting required in making the boxes is to file the touching angles of the pins so as to fit one standard top box, and the projections on the top boxes to be all fitted to one standard bottom box.

It has to be noticed that in the ordinary plan of moulding, and by the "odd-side" and "plate" methods, one side of a pattern is not available while the other is in use; by the new process each pattern is equal to two, as it will be evident that both blocks may be worked from at the same time.

Mr. Jobson exhibited a number of specimens of castings rough from the mould, to show the unusually small amount of fin upon them, and the good quality of the castings obtained by the new process of moulding. Also several of the plaster ramming-blocks were exhibited of the different kinds, and a pair shown in operation, showing the quickness of the process of moulding from them, and the perfection of the sand moulds obtained.

The CHAIRMAN thought the process was certainly very efficient in insuring expedition and accuracy, and the moulding was remarkably perfect; there must be an important economy both in the cost of moulding and in the cost of dressing the castings, which were turned out remarkably clean and free from fin.

Mr. JOBSON said that in the ornamental castings the dressing formerly cost as much as £10 per ton, from the fin left in the old process of moulding, but this expense was now mostly saved, as there was practically no fin left with the new plan; the specimens exhibited showed the ordinary average work produced, and the castings were just in the state in which they left the mould, not having had any trimming or dressing. For particularly fine work a sulphur face was used for the ramming-block instead of plaster, a small thickness of sulphur being first run on to form the face of the block, like the metal facing used in those blocks from which a very large number of moulds were required to be rammed.

Mr. R. BROWN thought it was an excellent plan of moulding for light work, and would be very advantageous and economical for that kind of work to which it was more particularly applicable.

Mr. JOBSON said that whenever a large number of castings were required from one pattern, the new process of moulding was found a great advantage; it had been applied at present to light ornamental castings for fender and stove fronts, &c., and for thin plain castings, such as gutters and spouting, it was very advantageous, as it insured such uniformity in the thickness of the metal throughout, that the castings could be made considerably lighter than was practicable in the ordinary method, with a great saving in the cost of moulding.

The CHAIRMAN inquired what was the largest casting to which the plan had yet been applied? He did not see why it should not be applicable to large castings, such as girders, where they had sometimes to cast a considerable number from the same pattern.

Mr. JOBSON replied that the largest size of casting at present moulded by the new process was about 3 ft. 6in. square, and 8ft. by 1 ft.; with large castings there was seldom perhaps a case of a sufficient quantity from one pattern, or it might be advantageous to apply the plan.

The CHAIRMAN said the only moulding that he had seen approaching it in the rapidity of the work, was a plan he had lately seen in opera-

tion at Manchester, in moulding a new construction of railway sleepers, where the pattern was withdrawn by a screw working in slides, without rapping, or the manipulation of ordinary moulding.

Mr. Hodgkin remarked that he remembered a plan something similar, that was used at Ipswich by Ransomes and May, in casting Barlow's sleeper chairs, where a large number had to be cast from one pattern; three odd-side boxes were used in that case, and each set of boxes was rammed up by a different gang of men, causing a very material saving of time and labour.

Mr. Jobson observed that a particular advantage in the new process of moulding was that it did not signify how irregular the parting surface was, or how inaccurately the first parting might be made, as the second block being a plaster cast taken from it must fit it perfectly in every part; and the plaster ramming-blocks gave great facility for preventing any fin on the castings, by merely scraping off a little from the surface of the plaster block, wherever any fin might be observed in the first casting.

The Chairman proposed a vote of thanks to Mr. Jobson, and to Mr. John Jobson, for the specimens, &c., he had sent, which was passed.

The following paper, by Mr. John Ramsbottom, of Manchester, was then read :—

ON AN IMPROVED PISTON FOR STEAM-ENGINES.

The importance of having the piston of a steam-engine, upon which its satisfactory performance so much depends, made as light, as simple, as steam-tight, and as free from friction as possible, will no doubt be generally admitted, and by none more readily than those who, like the writer, have charge of locomotive engines.

The piston which is the subject of the present paper goes far to secure these advantages, and has realised so far as time would allow all that the writer expected from its introduction. It has been his leading object to reduce as far as possible the amount of rubbing surface, preserving at the same time as nearly as practicable the same pressure per unit of surface, in order to prevent the passage of steam.

This has been done for an 18 inch piston in the proportion of about 141 to 42, and the friction, which may fairly be assumed as proportioned to the extent of rubbing surface, has been reduced accordingly.

This piston is shown in Plate 16, and consists of a single casting A, without cover, bolts, or nuts; it is fixed upon a conical part of the piston rod by a nut, as shown in Fig. 1. Three separate grooves B B B, each $\frac{1}{4}$ in. wide, $\frac{1}{4}$ in. apart, and 5-16 deep, are turned in the circumference, and these grooves are fitted with elastic packing rings. These rings, which may be made of brass, steel, or iron, are drawn of a suitable section to fit the grooves in the piston, and are bent in rollers to the proper curvature, the diameter of the circle to which they are bent being about one-tenth larger than the cylinder. They are placed in the grooves in a compressed state, and along with the body of the piston are thus put into the cylinder, care being taken to block the steam port so as to prevent the rings from getting into it. The rings are therefore forced outwards by their own elasticity, which is found quite sufficient to keep them steam-tight.

The joints of the rings are placed in some part of the lower half of the cylinder so as to break joint, as at D D D in Fig. 2. The body of the piston resting as it does upon the bottom of the cylinder, prevents the steam getting at them; should it however by any chance pass the joint of ths first ring, it is all but impossible for the solid part of the piston to be so far out of contact as to allow access to the second, and of course still more so to the third joint.

In applying this piston to engines with the ordinary flat covers, the form already described is preferred, and in order to fill up the recess in its inner side and prevent waste of steam, a block C C is riveted to the inner cover. The front cover having no block attached to it is not increased in weight, and is therefore more easy to handle. When, however, the covers are adapted to the piston, the form shown in Fig. 3 is considered best, as it may be made rather lighter.

The advantages obtained in this piston are:—

1st.—Lightness, a 15 in. piston of cast iron weighs only 88 lbs. on the new construction, and the lightest the writer had previously in use weighed over 119 lbs. If made of wrought-iron or brass the weight might be still further reduced.

2nd.—Simplicity and economy of construction; the piston consisting only of one piece with the three rings, and having no workmanship upon it except turning the rim and boring the centre. The packing rings being drawn as ordinary wire and then bent, can be produced at a cost little more than nominal.

3rd.—Impossibility of getting deranged, in consequence of there being no loose parts, such as bolts, nuts, cotters, or pins, which might come out, and cause damage; and no parts that can become unfastened, as each ring is effectually secured in a separate groove.

4th.—Less friction, both from the reduced weight of the piston and the less amount of elastic surface pressed against the cylinders. This latter for an 18 in. piston is about as 42 square inches to 141 square inches, when compared with an ordinary piston with packings $2\frac{1}{2}$ in. deep, and from the results shown in the working the writer is of opinion that it is mainly to this that its satisfactory performance is owing.

It is now sixteen months since the first pair were put to work, and others have since been made to the number of 30 pairs, the whole of which are realising all that could be desired. The piston now shown has been at work fifteen months, and has run a distance of 19,650 miles. A set of rings will run from 3,000 to 4,000 miles, and cost when new, about 2s. 6d.; so that in examining and cleaning a piston the renewal of the packing is of little more consideration, so far as cost is concerned, than if the piston were hemp-packed.

A careful average of the consumption of the fifteen engines which were first fitted with these pistons, and which have since run intervals of time varying from four to sixteen months, and an aggregate distance of 269,800 miles, shows a reduction, when compared with the duty of the same engines for four years previous to these pistons being put in, of 5·7 lbs. per mile; a result which has been carefully arrived at, and which goes to show that this piston, either from greater average tightness, or reduced friction, or both combined, is greatly superior to those which it has superseded.

Mr. Ramsbottom showed a new specimen of the pistons, and also one of them that had been 15 months at work, with the old and new packing rings.

The CHAIRMAN inquired whether the particulars of the working of the same engines before and after the new pistons were applied could be given, so as to enable a complete comparison to be made?

Mr. RAMSBOTTOM showed a statement of the consumption of fuel in the engines with the new pistons, since the alteration, and for four years previously, showing the general result of an economy in consumption of 12 per cent., where there had been no material repair or other alteration made to the engines.

Mr. JOBSON thought the difference appeared too great to be attributable entirely to any improvement in the construction of pistons, unless the engines were much out of order previously.

Mr. RAMSBOTTOM said the engines were in average good order both before and after the alteration of the pistons, and he was not aware of any other cause for the economy that was perceived. There were now upon various railways about 120 of the new pistons at work, which he believed had all proved quite satisfactory.

Mr. EVERITT inquired whether any trial had been made of the new pistons in stationary engines?

Mr. RAMSBOTTOM replied that only one or two had been tried at present in stationary engines; the largest of the pistons yet made was 18 inches diameter.

Mr. MATHEWS asked whether the new construction of piston was considered more applicable to locomotive than to stationary engines?

Mr. RAMSBOTTOM said the horizontal position, as in the locomotive engines, was best for it, as the piston body then completely closed the joints in the rings, all the joints being placed in the lower half of the circumference; only one vertical engine and a steam hammer, he believed, had been tried at present with the new piston, but no difficulty had been found in keeping them steam-tight. One great advantage was the lightness of the new piston, which was more particularly valuable in locomotive engines; the 18-inch pistons weighed only 121 lbs. each, instead of about 260 lbs., the usual weight, being a saving of more than half the weight.

The CHAIRMAN inquired what was the comparative cost of the pistons?

Mr. RAMSBOTTOM replied the actual comparison would vary with the different construction of piston, but none of the others he had in use were

less than three times the cost of the new pistons. The great saving in cost arose from the new piston having no fitting about it, and the only work put upon it was boring the centre and turning the circumference; the packing rings were merely iron wire, finished by the process of drawing, and only requiring to be bent to the proper curvature by passing through bending rolls.

Mr. PAYNE asked whether the packing rings were increased in thickness in proportion to the size of the cylinder?

Mr. RAMSBOTTOM said he had only yet tried one size of ring, and this had been found sufficient, as the diameters of cylinders had only varied from 12 to 18 inches; but for much larger cylinders a different size of packing ring would doubtless be advisable.

Mr. CHELLINGWORTH inquired whether any provision was made for preventing the rings from turning round, so as to avoid the risk of the open joints of the rings getting opposite one another?

Mr. RAMSBOTTOM replied, that some of the pistons had been made at first with only two rings instead of three, and it had been originally intended to have a stud riveted into each groove, to prevent the rings from turning round; this had not been found requisite, and therefore had not been carried out. Indeed, it was just as well that the rings should shift a little, as the working faces were thereby improved; even if the three joints should get all opposite at any time, which was very improbable, the total leakage of steam could be only very insignificant in that construction of piston.

Mr. MATHEWS remarked, that the same action which had the effect of turning round the rings, would also separate the joints from one another, and prevent any escape of steam from their simultaneous exposure at the same point.

The CHAIRMAN said, he thought the piston was a very ingenious invention, and its great simplicity and lightness was a great recommendation, and would make it very advantageous for several situations. He proposed a vote of thanks to Mr. Ramsbottom, which was passed.

The following paper, by Mr. Archibald Slate, was then read:—

ON AN IMPROVED WATER FILTER.

The subject of Water Filters is one of considerable importance, having received much attention, and it has been the subject of many ingenious inventions. It will be unnecessary to urge the necessity and advantage of filtering water both for domestic and manufacturing purposes, and the desirability of obtaining an efficient, convenient, and economical means of removing from the water all mechanical impurities.

The Filter that forms the subject of the present paper,—the original invention of Mr. James Forster, of Liverpool,—consists of a small apparatus attached to the cock from which the supply of water is drawn, the water being passed through the filter at the time of discharge.

The construction of the filter is shown in Plate 17; the filtering material consists of a hollow stone cylinder A A, about 4 ins. diameter, 7 ins. long, and $\frac{3}{4}$ in. thick, with a rounded close end below, and cemented at top into a groove in the cast-iron cap B B. This cap has a brass delivery pipe C communicating with the interior of the stone cylinder, and bent to prevent the escape of water when not required.

D D is a cast-iron base into which the supply pipe and cock E is fixed; and a cylindrical tin casing F F is fixed in a groove in the cap and base, and is secured by the frame and screw G G, connected by two side pins to the base, and screwed down upon the centre of the cap, making the joints water-tight.

When the supply cock E is opened, the water fills the outer casing, filters through the stone cylinder, and is discharged by the delivery pipe C; the stone being a fine-grained pure sandstone, suitable for the purpose, retains all the impurities of the water upon the outer surface, and delivers the water in a pure, clear stream. The action of the filter is an imitation of a pure spring issuing from a sandstone rock, which may be considered as a natural pressure-filter.

There is an important advantage in filtering water immediately before using it, as its freshness is then insured; but this is liable to be impaired, if the water is filtered previously, and stored up until drawn off for use. With the use of such a filter, whatever may be the state of the water in the mains, from the opening of them for repairs and other causes, a supply of pure water is always obtained for use.

The practical value of a filter is greatly influenced by the facility with which it can be kept clean; and in the present filter this object has been more particularly aimed at; the process of cleaning it is very simple, and can be effected by any person in a few minutes. The filter may work for some months before requiring to be cleaned; the general plan is to clean the filter when the water is found not to flow freely from it.

The top screw G is then loosened and the frame turned on one side, which allows the iron cap with the stone cylinder attached to be lifted out of the casing (as shown detached and inverted in Fig. 4), and the outer surface of the stone is then scrubbed with a piece of sandstone, and well washed, which removes all the deposit, and leaves it as clean and ready for use as at first. Previous to loosening the top screw, the small screw-plug H is open at the bottom to let the water out of the casing, and the screw I opened to let in air.

The deposit from impurities from the water is found to take place entirely on the outer surface of the stone, and penetrates only a very slight depth into the stone, so that it can be readily and completely cleaned by scrubbing the surface with sandstone.

When the water to be filtered is very dirty, the stone cylinder is encased in a flannel bag, which prevents the larger portion of the deposit from lodging on the stone, and saves trouble in cleaning, as well as enabling the filter to continue in action longer. In cases where the water is somewhat infected, by being exposed to any decaying organic matter, some animal charcoal is placed in a bag, or a flat perforated box, in the bottom of the filter, so that the water is purified by passing through the charcoal, before entering the filtering stone.

These filters have been in use for the last three years, and have proved quite satisfactory under all circumstances; several of them were in constant use in the Exhibition of 1851, and a number have been in use in Liverpool for some months. They are applicable for general domestic use, as the pressure required for filtering is so small, that any house having water laid on from water-works, or even a rain-water cistern at a moderate height, would have sufficient pressure for working this filter; it is working at Lambeth, with a pressure of only 9 feet, and at the Board of Health, under about 15 feet head. The small size of the filter, and its convenience of application, make it suitable for any situation.

It appears also from experiment, that in the cases where the water is soft, and has become impregnated with carbonate of lead, from contact with leaden pipes or cisterns, this is entirely separated by the stone filter—an important sanitary advantage.

The CHAIRMAN remarked, that he had brought the present plan before the meeting, in consequence of the subject of water-filters having been referred to in the discussion at the last meeting, and this was brought forward as a simple construction of filter which could be readily and frequently cleaned, so as to preserve it always in good action.

Mr. FORSTER exhibited a specimen of the filter, and showed the process of cleaning it when required.

Mr. BIRD inquired how long the filter was found to work before cleaning? how many gallons of water could be passed through it before the stone required taking out and cleaning?

Mr. FORSTER said, that he had not had an opportunity of ascertaining the quantity of water, but could state that one of the filters fixed in Liverpool had been supplying all the water for a large household during three months before requiring cleaning. The time of cleaning would of course depend on the quality of the water, but as far as his experience went, the filters for domestic purposes would not require cleaning oftener than every two or three months with the ordinary quality of water.

Mr. BIRD observed, there was no difficulty in obtaining a good filtering medium, but the difficulty was to get a filter that would keep at work without requiring renewing or cleaning so frequently as to limit greatly its practical application; he had tried a great many experiments on the subject, with a variety of materials, and found this was the principal difficulty. He had tried sandstone as a filter, in a disc of 9 inches diameter and $\frac{1}{2}$ inch thick, but found it was nearly stopped by the accumulation of deposit in about 12 hours, when about 400 gallons had passed through; and unless the sandstone were much purer and less calcareous than could be procured in this district, he did not understand how it could be kept at work any length of time. He thought the most important practical test of a filter was the quantity of water that it would filter before requiring cleaning or renewing, as well as the convenience of effecting the cleaning.

Mr. ADDENBROOKE thought a filter that did become choked would be preferable, as that was a proof it was doing its duty.

Mr. FORSTER said he had endeavoured to get a measure of the quantity passed through, but had not been able to do so, from the long time that the filter kept at work before requiring cleaning.

The CHAIRMAN observed that it appeared to him the more important point was to have a filter that could be very readily taken to pieces, cleaned, and put to work again, rather than one which would continue a long time before requiring to be cleaned.

Mr. CLIFT thought that perhaps the oftener a filter required cleaning the better, as the object was to obtain fresh pure water.

The CHAIRMAN said that the object in that filter had been to facilitate and encourage the frequent cleaning of the filter: it was better to get it cleaned out too frequently, so as to insure its being kept in good condition, than to risk the accumulation of any animal or vegetable matter in the filter from any accidental neglect. The trouble and expense generally attending the cleaning or renewal of filters had led to the custom of requiring them to work for a long time before cleaning; but he thought that with a filter that could be taken to pieces and cleaned by any person in a few minutes, such as the present one, it might have even a weekly cleaning as a regular rule.

Mr. JOBSON inquired what was the pressure of water where the filters had been tried in Liverpool?

Mr. FORSTER replied that the pressure was 170 feet head, but a very moderate head, about 15 feet, or only the height of one story, was found to give sufficient pressure for an ordinary supply of water in a house.

The CHAIRMAN said he hoped the exact facts would be ascertained, for another occasion, about the quantity of water passed through the filter before cleaning.

A vote of thanks to Mr. Forster was proposed and passed.

The Meeting then terminated.

BIRMINGHAM STATION ROOF.

Fig. 1. *General Plan*

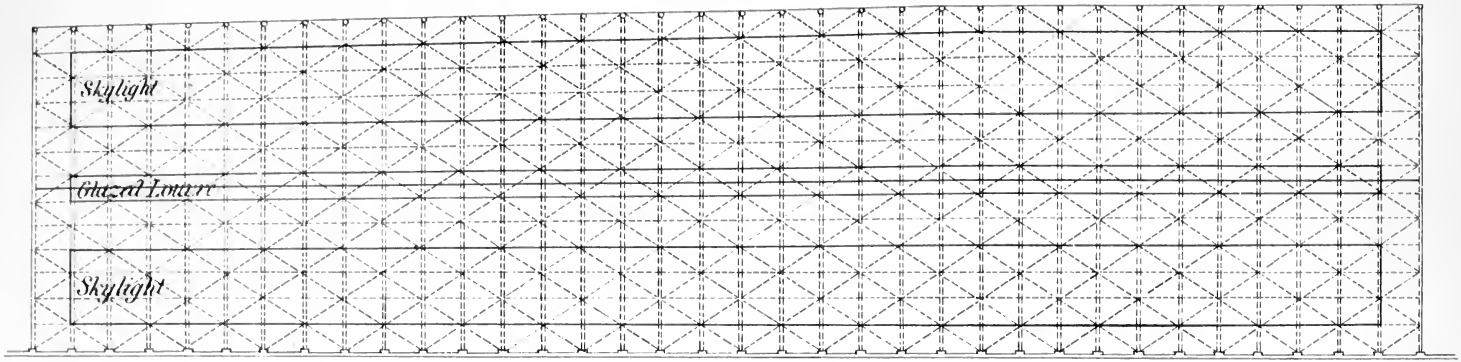
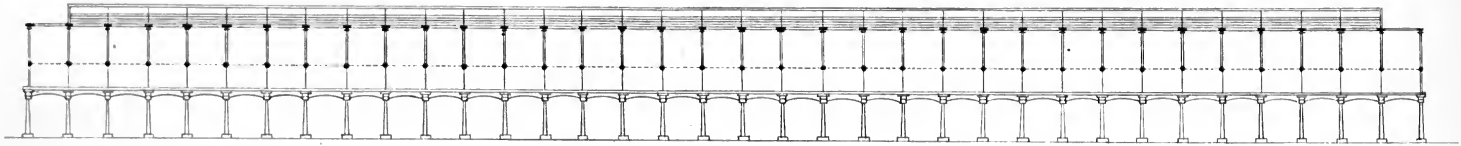


Fig. 2. *Longitudinal Section.*



Scale 1/1350th 100 50 0 100 200 300 400 Feet

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Plate 18.

Fig. 3. *Transverse Section.*

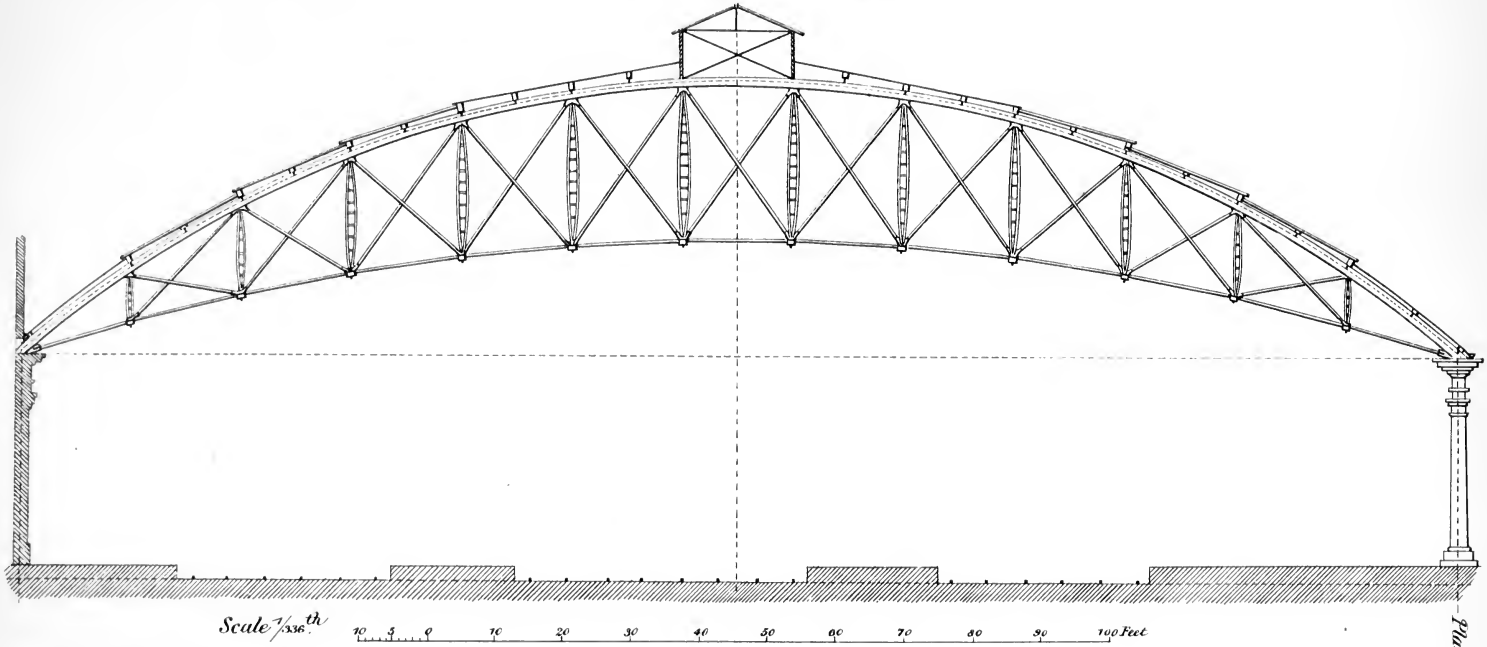

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Plate 19.

Fig. 4. *Foot of Principal at Wall*

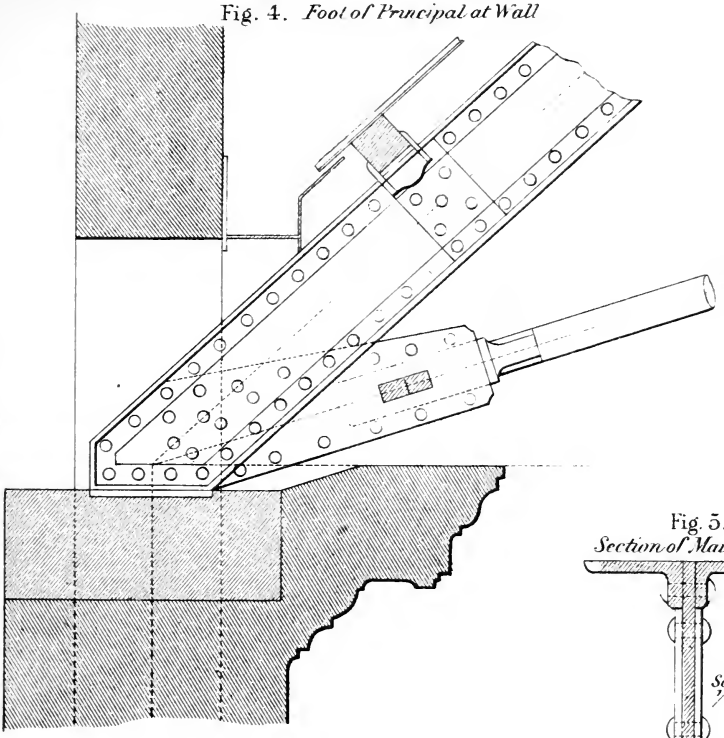

Fig. 5.
Section of Main Rib

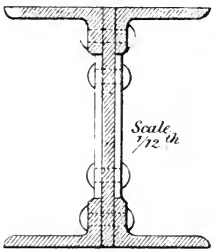

Fig. 7.
End view of Fig. 6.

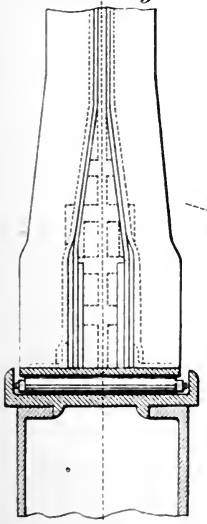

Fig. 6
Foot of Principal at Column

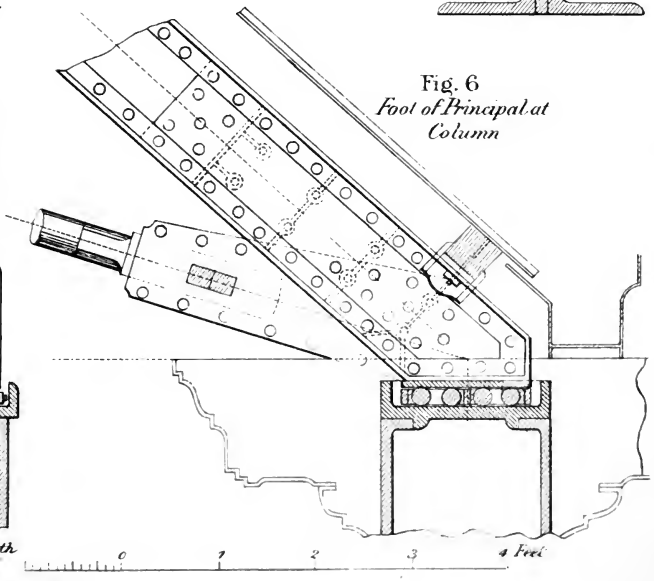

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Fig. 8. *Elevation of Purlin*

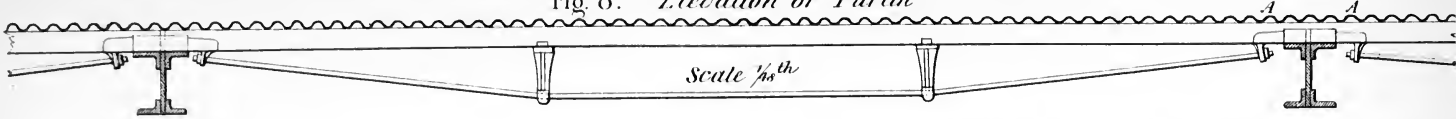


Fig. 12.
Transverse Section

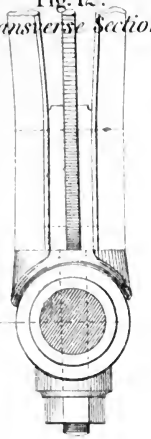


Fig. 11. *Coupling of Tie Rod*

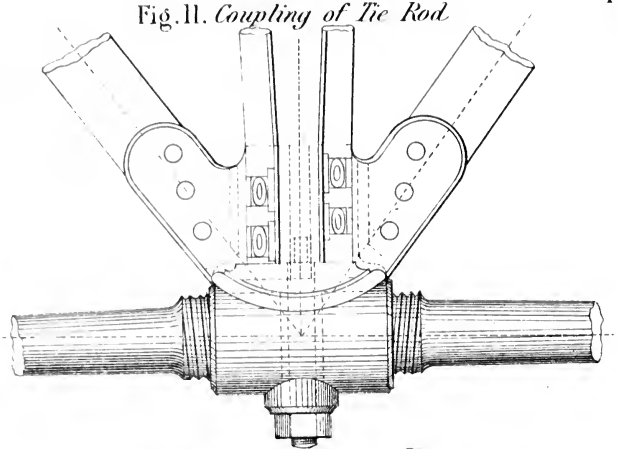


Fig. 10. *Section at A.A.*

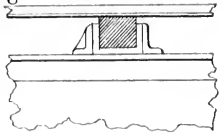
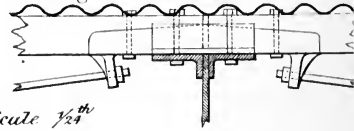


Fig. 9. *Elevation at A.A.*



Scale 1/24th

Fig. 14.
Plan of Cross

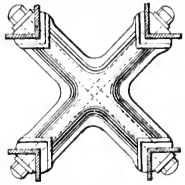


Fig. 15.
Elevation of Strut Showing Cross

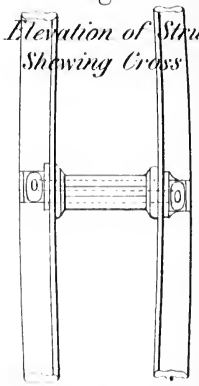
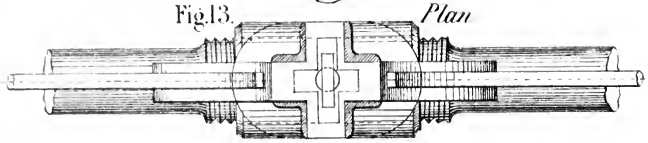


Fig. 13. *Plan*

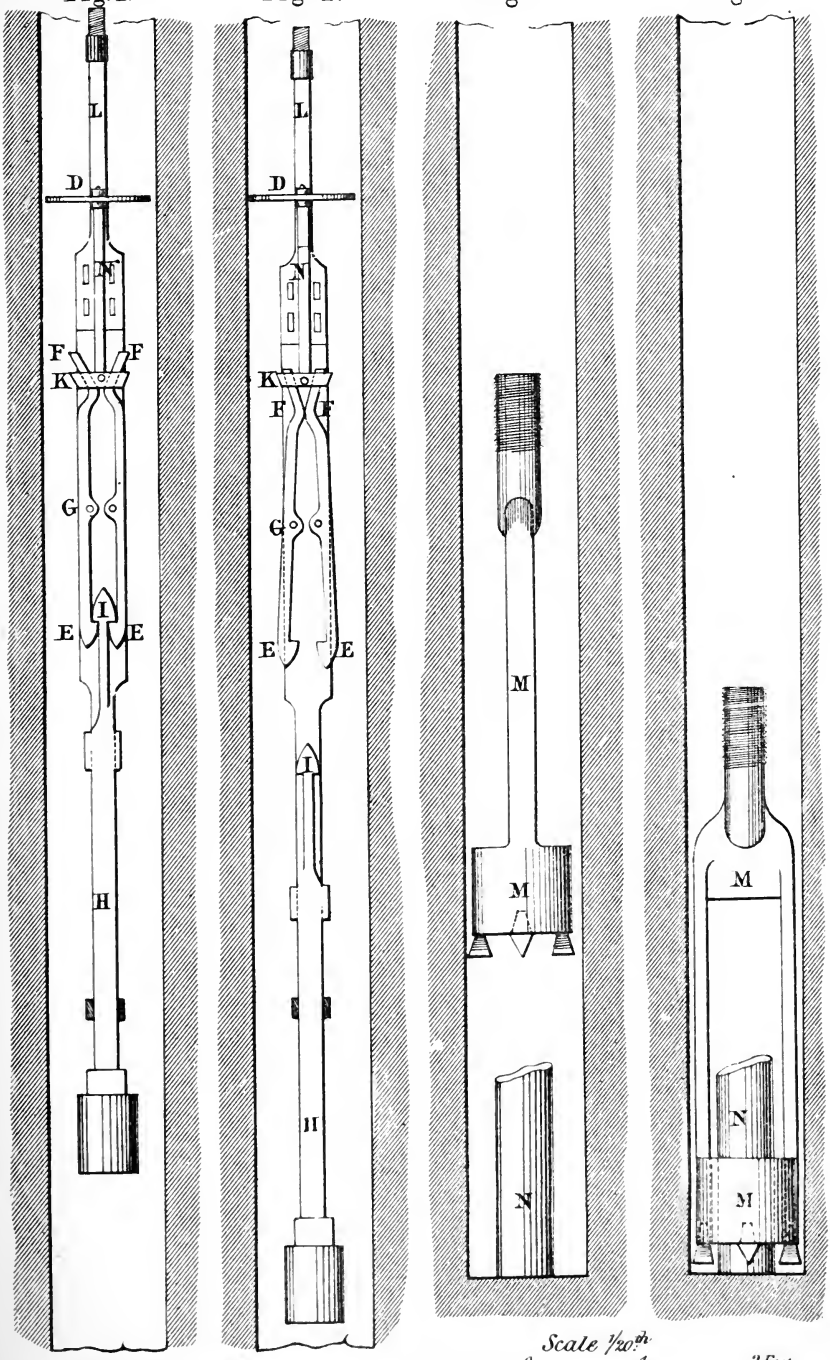


(Proceedings Inst. M.E. 1854 Page 81)

Scale 1/12th 0 1 2 Feet

KIND'S BORING APPARATUS. *Plate 22.*

Fig. 1. Fig. 2. Fig. 3. Fig. 4.



Scale 1/20th

0 1 2 Feet

(Proceedings Inst. M.E. 1854, Page 89.)

Fig. 5.
Boring Tool

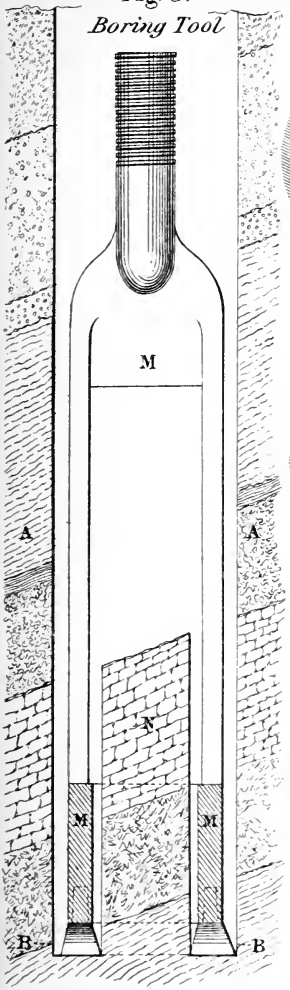


Fig. 7.
Plan at A A.

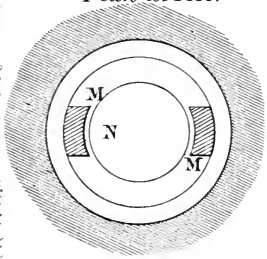


Fig. 8.
Plan at B.B. (inverted.)

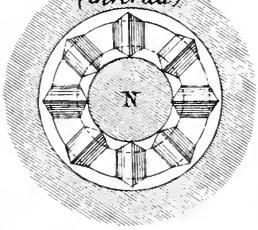


Fig. 9.
Plan at C.C.

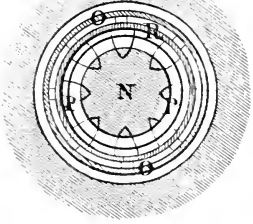
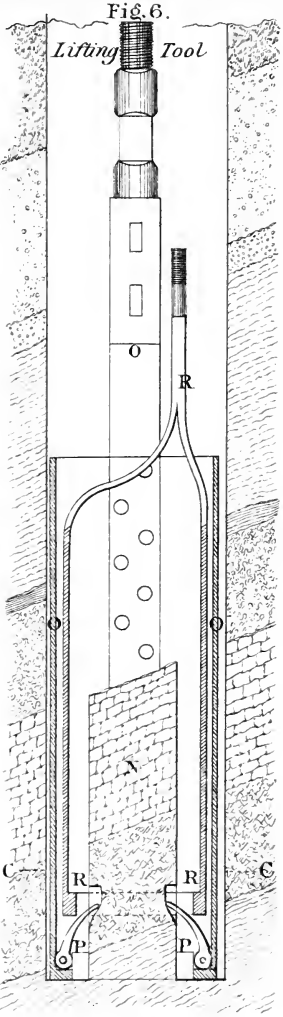


Fig. 6.
Lifting Tool



Scale 1/13th 12 9 6 3 0 1 2 Feet

FUSIBLE PLUG FOR STEAM BOILERS.

Fig. 10. *Section*

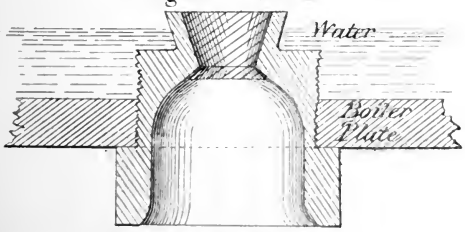
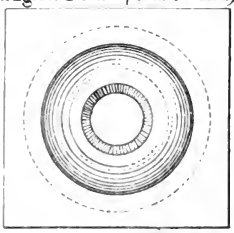


Fig. 11. *Plan (inverted)*

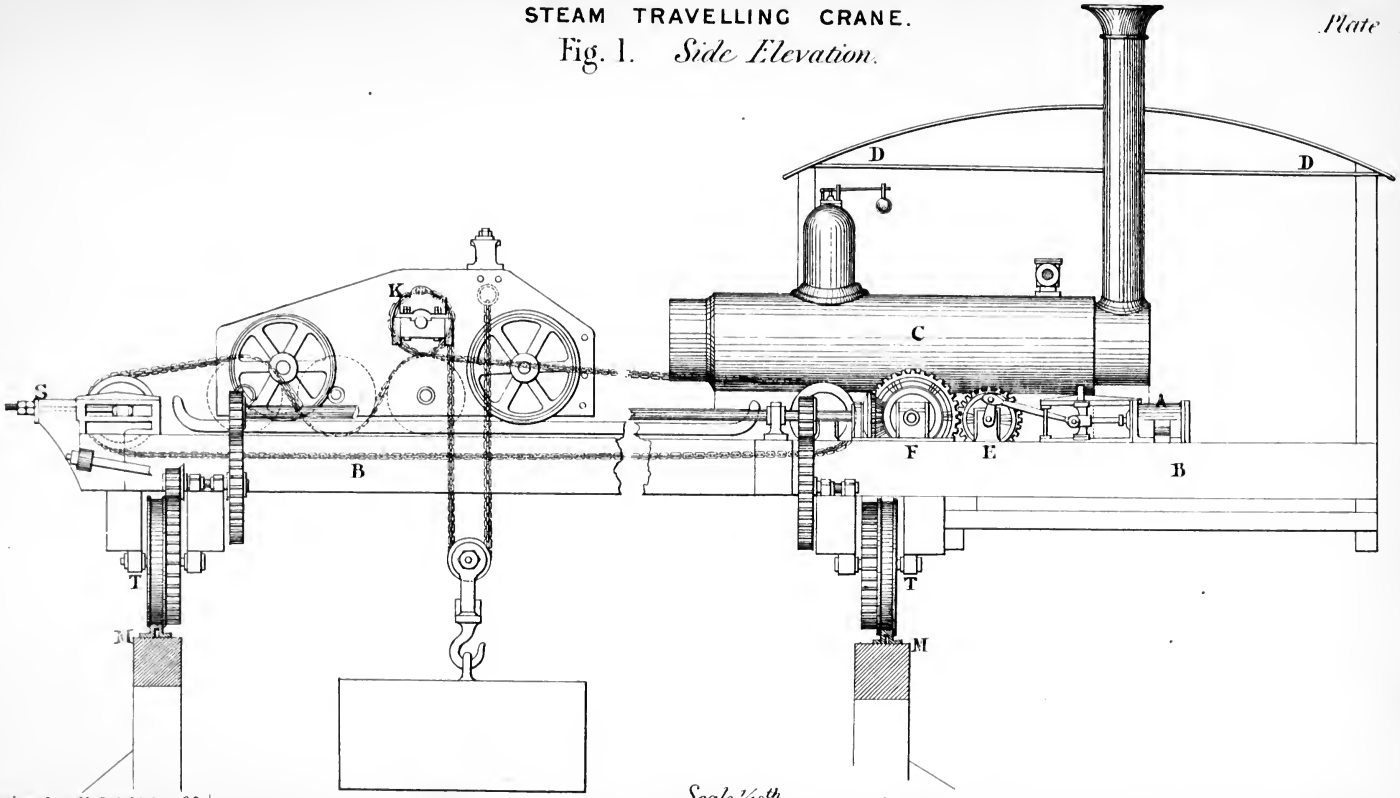


(Proceedings Inst. M.E. 1854 Page 90.)

Scale ½ size

STEAM TRAVELLING CRANE.

Fig. 1. *Side Elevation.*



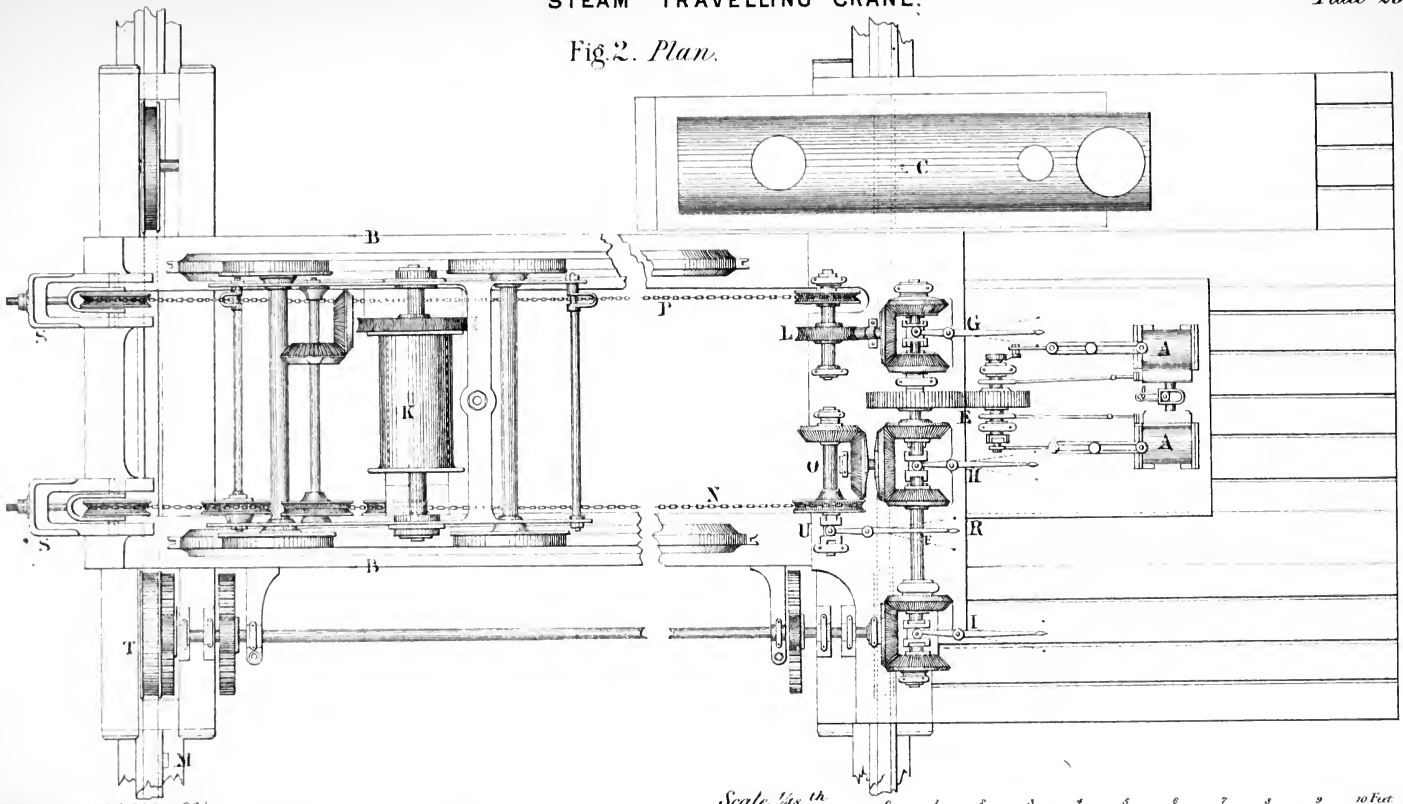
(Proceedings Inst. M. E. 1854. Page 96.)

Scale 1/48th 0 1 2 3 4 5 6 7 8 9 10 Feet

Plate 24.

STEAM TRAVELLING CRANE.

Fig. 2. *Plan.*



(Proceedings Inst. M.E. 1854 Page 96)

Plate 25.

PROCEEDINGS.

July 26, 1854.

The General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, July 26, 1854, William Fairbairn, Esq., President, in the Chair.

The Minutes of the last General Meeting were read by the Secretary, and were confirmed.

The Chairman announced that the Ballot-papers had been opened by the Committee appointed for the purpose, and the following new Members were duly elected:—

MEMBERS.

John Cochrane, Norwood.
John Jobson, Derby.
Thomas Spencer, Newcastle-on-Tyne.
Joseph F. Strong, Birmingham.
James J. Wallis, Birmingham.

The following Paper, by Mr. Edward A. Cowper, of London, was then read:—

DESCRIPTION OF THE WROUGHT-IRON ROOF OVER THE CENTRAL RAILWAY STATION AT BIRMINGHAM.

This roof, which covers the New Street Station, recently opened in Birmingham, is in one span, without intermediate supports, being considerably larger than any roof previously constructed; and on this account the present description of the construction is laid before the Institution as a record, by the Author, by whom the original drawings and calculations were made for the contractors, Messrs. Fox, Henderson, and Co.

Under the roof are 10 parallel lines of railway, with 4 platforms, and a carriage road, extending the whole length of the roof, for the accommodation of the traffic of three railways, with trains to and from six different directions, (London, Liverpool, Derby, Bristol, Dudley, and Walsall,) and having 170 trains arriving or departing daily.

The general plan of the roof is shown in Fig. 1, Plate 18, and an enlarged transverse section in Fig 3, Plate 19.

The whole length of the roof is 864 feet, and it is constructed of 36 principals fixed at 24 feet distance from each other.

The span of the principals varies from 211 feet to 191 feet. The ground being irregular in plan, and the space valuable, the outline of the roof was made to follow its boundary, and the roof is constructed tapering in two different proportions, as shown by the plan, Fig. 1. The lengths of the several principals are consequently all different, the greatest span being 211 feet at one end of the roof, and the span diminishing to 191 feet at the other end.

All the principals are *similar*, each successive one from the largest being reduced proportionately in the length of every part, so that the lines in each portion converge to one point; and, in consequence, the effect of the irregularity in outline is not perceptible under the roof, and is only observed on examining the outside, at the back.

The roof is supported on one side upon brick pilasters, projecting from the wall of the office buildings, and on the other side upon hollow cast-iron columns, 2 feet diameter, and $5\frac{1}{2}$ tons weight each, which are connected together by cast-iron arched girders. The height of the springing of the principals is 33 feet above the level of the railway; the rise of the tie-rod, which forms a curve, is 17 feet in the centre of the largest principal, and the depth of the curved principal is 23 feet, making the rise of the main rib 40 feet, and the total height is 84 feet to the top of the louvre in the centre of the roof.

The main rib of each principal is shown in Fig. 5, Plate 20, and consists of a vertical plate of wrought iron, 15 inches deep, and 11-16ths of an inch thick, with two angle irons 6 by 3 inches, rivetted upon each edge, forming a flange at top and bottom $12\frac{3}{4}$ inches wide;

the junctions of the angle-irons are made to break joint with one another, and junction plates are rivetted on each side of the vertical rib, at the joinings, as shown in Fig 5.

The tie-rod is 4 inches diameter, enlarged at the ends where screwed, so as to preserve the full sectional area at the bottom of the thread; the several portions of the tie-rod are joined at the foot of each strut by a wrought-iron coupling-box, with a right and left-handed screw, shown in Figs. 11, 12, and 13, Plate 21.

There are in each principal 12 vertical struts, each constructed of four angle-irons set diagonally in the four angles of a square, and separated by series of small cast-iron crosses secured by bolts passing through the hollow arms of the cross, shown in Figs. 14 and 15; these struts are enlarged in the middle, to give the requisite strength, by proportioning the length of the crosses, so as to give a curved outline. Each end of the strut is secured to a cast-iron shoe, the upper one being bolted to the bottom flange of the main rib, and the lower one clips the coupling box of the tie-rod, as shown in Figs. 11, 12, and 13. The diagonals in the principals are of flat iron, $\frac{5}{8}$ inch thick, and from 3 to 5 inches wide; they are rivetted together where they cross, and attached at each end by bolts to lugs upon the cast-iron shoes.

The foot of each principal on the wall side, is shown in Fig. 4, Plate 20, and has a cast-iron bed-plate rivetted on the underside, which is recessed into a stone, built into the top of the pilaster. The foot of the principal at the column, is shown in Figs. 6 and 7, and has a flat wrought-iron bed-plate, resting upon four wrought-iron rollers, 2 inches diameter, and 19 inches long, which work upon a corresponding cast-iron plate, fixed on the top of the column, to allow for the expansion and contraction of the principal, from variation in temperature.

The purlins, shown in Fig. 8, Plate 21, are fixed at 10 feet intervals, and consist each of a wood batten, 6 inches square, trussed with a $\frac{3}{4}$ inch iron rod; the cast-iron shoe at each end clips the back of the principal, and it is bolted to it, serving as an abutment for the two adjoining purlins, shown in Figs. 9 and 10.

A large louvre, for ventilation, 5 feet in height at the sides, is fixed along the whole length of the ridge, as shown in Figs. 1, 2,

and 3. Diagonal wind-ties, 1¼ inch diameter, extend over the whole roof, as shown in the plan Fig. 1, starting from the foot of every alternate principal, and bolted to the main ribs at each intersection.

One half of each side of the roof is glazed, and also the louvre in the centre, amounting to 7-13ths of the surface; the rest is covered with galvanized corrugated iron of the thickness of No. 18 wire gauge, which is nailed down upon wood purlins. The glass is rough-rolled fluted plate, from Messrs. Chance's works, 3-16th of an inch thick, or 44 oz. per foot, each plate being 6 feet long by 16 inches wide. The total area of glass is 94,000 square feet, weighing about 115 tons; the whole area of the roof is 175,600 square feet, or rather more than 4 acres.

The skylight is constructed in three portions on each side of the roof, each one being a plane about 17 feet wide, and the whole length of the roof, and at a less slope than the adjoining portion below, the least slope being 3 to 1; the corrugated iron between the skylight and the louvre is blocked up from the curved back of the principals at the upper portion, so as to form a uniform slope of 5 to 1, as shown in Fig. 3.

Each end of the roof is closed by a glazed screen down to the horizontal line of the springing. The erection of the roof was completed in May, 1854.

Mr. Cowper exhibited a number of large drawings showing the construction of the roof, and explained by a table the mode of calculating the series of dimensions required for the several parts, from the variation in size of the different principals. One principal was drawn out complete of the largest size, and one of the smallest size, in each of the two portions of the roof where the taper was regular, and then the dimensions of all the several parts being entered in the columns of a table, the largest principal being at the top of the table and the smallest at the bottom, the dimensions of all the intermediate principals were entered successively, by taking the difference between the largest and smallest dimensions in each column, and dividing this difference by the number of intermediate

bays, making the dimension of each one an arithmetical mean between those on each side of it. The first 11 principals diminished in span $1\frac{5}{8}$ inches each, and the rest $8\frac{3}{4}$ inches each. By this plan there was a considerable saving of time, as well as less risk of inaccuracy, than in drawing out and calculating each one of the principals separately; the dimensions were taken to 1-8th inch in each case, for the actual construction, which was found to be as accurate as was useful for the purpose. The number of different dimensions required for making each principal was about 60, and as there were 36 different principals, a total number of dimensions of upwards of 2000 was requisite for the lengths of the different portions alone.

The CHAIRMAN observed that the description of such a roof formed a very interesting and valuable record, the span of 211 feet being the largest by a considerable amount that had ever been erected. The roof of the Railway Station, at Liverpool, of 154 feet span, was the largest span he was acquainted with previously, and at the time that was in construction he remembered being engaged, together with Mr. Locke, in a number of experiments for the purpose of fully testing the strength of the roof at Messrs. Turner's, at Dublin, where it was made. A portion of the roof was erected temporarily, and it was tested by suspending weights from it amounting to a load of 40lbs. upon every square foot of the external surface of the roof, including the weight of the materials and covering of the roof; the principals were found to stand this test satisfactorily, though it was considered a very severe one, and considerably greater strain than the roof would be ever likely to be subjected to when completed. He inquired whether the Birmingham Station roof had been similarly tested, and what were the results?

Mr. COWPER showed a diagram of the results of testing the principals which had been effected by erecting three of them upon the ground and loading the centre one with weights suspended from the bottom of each of the struts, the other two principals serving to hold the centre one vertical, without assisting to support the load. A weight of 45 tons was first applied, distributed uniformly along the whole length, which amounted to a load of 20lbs. per square foot upon the roof, independent of the weight of the roof itself, and

the deflection with this was $1\frac{1}{2}$ inches in the centre in the whole span of 211 feet. A load of 67 tons, distributed, amounting to 30lbs. per square foot made a deflection of $2\frac{5}{16}$ inches; and the extreme load of 90 tons, or 40lbs. per square foot, in addition to the weight of the principal, amounting to about 25 tons more, gave a total deflection of $3\frac{5}{16}$ inches; the total load in this case including the principal was 115 tons, amounting to more than 50lbs. per square foot, but it was found when the weight was removed, after having been left on some hours, that no perceptible set had taken place, and the principal recovered its original form. This unusual result was caused probably by the circumstance that the weight of the principal itself, 25 tons, was sufficient to take up all the slack in the several joints, and bring all the parts to a full bearing. The sections of metal in the differents parts were proportioned equally to the respective strains; so that the strain per square inch upon the material was nowhere sufficient to produce permanent extension or compression, with the amount of load applied; the total strain, including the covering, not exceeding $8\frac{1}{2}$ tons per sectional inch on the parts in tension, and 4 tons per sectional inch on the parts in compression.

Another test that was applied to the principal, perhaps even more severe than the maximum distributed load, was a load of 45 tons on the north side with only 11 tons on the south side; the greatest deflection was then 3 inches at about one-fourth the length on north side of the centre, and $2\frac{1}{6}$ inches deflection at a corresponding distance on the south side. A load of 22 tons was then placed on the south side with the same load as before, 45 tons, on the north side; the deflections were in that case 3 inches and $2\frac{1}{2}$ inches respectively at the same points as before. The remarkably small extent of distortion in the principal under this very severe test showed satisfactorily its rigidity and stiffness to resist irregular oblique strains, an unbalanced excess of load on one side amounting to 34 tons, having caused a distortion of only $\frac{1}{2}$ inch above and below a uniform curve of deflection. The total extension in the length of the principal on the base was $2\frac{5}{8}$ inches with the greatest weight.

Mr. McConnell inquired how the lengths of the different por-

tions of the tie rods were adjusted so as to bring a uniform strain on each part?

Mr. Cowper explained that it was accomplished by a right and left handed thread in the large coupling screw that joined the portions of the tie rod at the foot of each strut, which gave the means of tightening up *separately* each bay of the principal. This was found a very serviceable and perfect adjustment for keeping all the principals in correct line throughout the roof, which would have been very difficult to accomplish without that complete means of adjustment; each principal was first put together on the ground and all the parts correctly fitted, and then by marking the position of the thread in the coupling screws of the tie-rod before taken to pieces, each part was readily fixed again in its right position in erecting the roof. He had first adopted that construction in making the large roof of the Tithebarn Street Station, at Liverpool, which was 136 feet span at one end, rather less than the Lime Street Station roof previously referred to; it had two separate tapers in the whole length.

The CHAIRMAN observed that the main rib of the principals was constructed of several pieces rivetted together, instead of I shaped iron rolled for the purpose, as in the Lime Street roof; and he inquired how the compound rib had been found to answer?

Mr. COWPER said that iron rolled of that form was considerably more expensive than the compound rivetted rib, when of the size required for roofs of such large span, and the rivetted construction had proved satisfactory. It was on the same principle as the wrought-iron box girders, and all the joints were well broken by making the joints of the several pieces pass one another a long way; the ends of all the pieces were planed so that the joints were a perfect butt; the ends of eight pieces being planed at once to the same angle, made the work simple and accurate. The roof of the large slip, No. 4, at Woolwich Dockyard, was the first constructed with the compound angle iron struts; it was 84 feet span, with 28 feet bays. In the erection of the Birmingham roof, the large main ribs were hoisted in five separate pieces, which were then rivetted together in their places; some of these heavy pieces were hoisted at once to the full height, by means of a locomotive engine taking

hold of the rope from the snatch-block, and running it straight out 200 or 300 yards.

The CHAIRMAN asked who was the designer of the Birmingham Station roof, and what was the comparative increase in cost from making the whole roof in one span instead of having intermediate rows of columns?

Mr. COWPER replied that he had designed the present roof for the makers, Messrs. Fox, Henderson, and Co., but it had been practically carried out since he left them; they had been applied to by the Railway Co. for a design for a roof to cover the whole area, before it was decided to make the roof in a single span; the lines of railway and paltforms were straight and parallel under the greater portion of the roof, and would have allowed of intermediate rows of columns to support the roof, but the curvature of the lines at the end converging into the entrance tunnel prevented the use of intermediate columns at that part, and it was finally determined to have the whole roof in one span. He did not know the exact comparison of cost, but the adoption of a single span for the whole roof did not increase the cost more than 25 or 30 per cent. The present roof was of very economical construction, although 211 feet span.

Mr. MCCONNELL inquired whether it was found that sufficient allowance had been made for expansion by heat, and the alteration in strain that might arise from unequal expansion and variation in form of the principals?

Mr. COWPER said that as the principal was all constructed of wrought-iron throughout, it might be expected to expand proportionably in each part, and therefore preserve always a *similar* form; the actual amount of expansion was probably less than would be expected from calculation. In the Crystal Palace no allowance whatever had been made for expansion in the large arched ribs, nor even in the whole length of the building, the longitudinal cast-iron girders and columns being all keyed fast together; but no evil had resulted from the expansion, and it could only be supposed that a sufficient springing of the material took place, or more probably a yielding in the multitude of joints.

The CHAIRMAN asked what actual variation in length from expansion was found to take place in the Birmingham roof? In

the Britannia Tubular Bridge a variation throughout the year of about 3 inches was observed at each end in the half-length of about 750 feet; the extent of motion was accurately measured by a scale fixed at each end upon the abutments, whilst the tube was fixed in the centre and sliding on rollers at each end.

Mr. COWPER said he did not know whether the extent of variation in length had been accurately measured, but he understood that only about $\frac{7}{8}$ inch had been observed; though calculation would give an extreme amount of 1 to $1\frac{1}{2}$ inches, at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ inch variation per 100 feet, with the change of temperature that was experienced in this climate.

The CHAIRMAN inquired how the ends of the main ribs were constructed to give a sufficient sectional area of metal at the feet of the principals for supporting the great weight they had to carry? and he asked what was the total weight of each principal with the covering?

Mr. COWPER replied that the ends of the main rib were enlarged by inserting a cast-iron wedge piece at the end of the vertical rib between two wrought-iron side plates, which spread out with the angle irons at top and bottom, giving a sufficient area of bed-plate for taking the whole pressure, and allowing the side pieces to be inserted to which the end of the tie rod was keyed. The weight of the covering on each bay of the roofing was about 15 tons, making with the principal of 25 tons, a total weight of about 40 tons, or 20 tons upon each end of the principals.

Mr. MC CONNELL remarked that the roof appeared to be an excellent example of material placed in the best form for obtaining the lightest and strongest construction of covering for a large area without supports; he proposed a vote of thanks to Mr. Cowper for his paper and excellent drawings, which was seconded by Mr. Lloyd, and passed.

The following paper, by Mr. Samuel H. Blackwell, of Dudley, was then read:—

ON KIND'S IMPROVED SYSTEM OF BORING.

There are few processes of greater importance in a mining country

and especially in one in which mining operations have been carried on for long periods, than that of Boring.

In all mining districts, the operations are, of course, at first principally confined to the mineral formations, whether beds or veins, which lie near the surface, and thus disclose themselves readily to view. But as these formations are followed deeper and deeper, and surface indications no longer act as guides, or only partially so, it becomes of the greatest importance that some easy and economical method should be employed, for the purpose of ascertaining whether minerals exist at points where no actual proofs of such have been given.

In England we possess mineral formations of greater value and importance than any other country, of equal area; these formations have been largely worked from the very earliest periods, and of late years to an extent which forms a completely new epoch in the history of industrial labour.

The extent to which our known mineral fields are now being worked, and the dependence of the continued prosperity of the country upon the further development of our mineral resources, make it of the greatest importance to avail ourselves of every improvement in the cost and despatch of any processes having for their object the discovery of new mineral fields.

The principal means of effecting such new discoveries is that of Boring, and yet far less attention has been paid to the improvement of the process of Boring in this country than on the Continent. The old processes are still almost universally employed; they are costly, not only in expenditure of money, but still more in the time they require which is oftentimes of even greater importance; they are also uncertain in their results, and in the knowledge which they give of the character of the measures passed through.

These defects in the present processes often lead to the risk of expensive sinkings being preferred to the delay and uncertainty of boring, under circumstances in which if economy, despatch, and certainty could be insured, boring would be invariably adopted.

The defects of the present English system arise from the permanent attachment of the boring chisel to the rods which are employed to lift and lower it; the blow is thus given not simply by the chisel itself, but by the entire length of rods and the chisel, forming together one single tool.

When great depths are attained, the jar and vibration communicated to the rods through their entire length, by their fall and the percussion of the chisel, are so great as to require corresponding strength and weight of material.

The space through which the rods are allowed to fall, must under these circumstances necessarily be small, as no strength of material would long withstand the constant jar and vibration consequent upon a fall through any great space, and thus in practice, a fall of a few inches only is all that is obtained.

The strength and weight of the rods are also limited by hand power being generally employed. The chisel used is thus always small, and the bore-hole correspondingly small, giving rise to much friction against the sides, and rendering the indications of the measures passed through uncertain, from their being ground up, more or less, by the action of the chisel.

Kind's improved system of Boring—the subject of the present paper—remedies all these defects.

The tool is free, and is attached to the rods simply whilst being lifted; the lifting can be effected to any height required, and when so lifted, the tool is detached from the rods, and falls freely by itself. It is then followed by the rods, which pick it up, and lift it again, for another fall. The rods may thus be made light, and the tool heavy, no vibration or jar being communicated to the rods by the percussion of the fall.

The tool can be made to fall through any amount of space, and the impetus thus obtained gives corresponding rapidity to the work performed.

Large bore-holes may thus be made, and cores of 6 to 10 inches in diameter taken out, so as to show the precise character of the beds passed through, and their exact kind of stratification.

These results will be apparent on reference to the accompanying drawings, showing the character of the tools employed.

Figs. 1 and 2, Plate 22, show the lower part of the rods L, on which the bar or slide N, (attached at its upper end to the piston D, and at its lower end to the wedge and ring K,) has the power of a slight upward and downward movement, so as to open or close as it ascends and descends, the fangs E F working upon the central pivots G.

When the fangs E F are closed by the downward pressure of the wedge and ring K, they firmly grasp the head I of the tool H, as in Fig. 1.

When the fangs E F are opened by the upward pressure of the wedge and ring K, the tool H is loosed by the fangs, and entirely detached by its own weight, as in Fig. 2.

The opening and closing of the fangs E F are effected by the action of water in the bore-hole, pressing on the piston D, either on its upper or lower surface.

If the tool be resting on the bottom of the bore-hole, detached from the rods, as shown in Fig. 4, as the rods descend to pick it up, the pressure of the water upon the piston D is on its under surface, and consequently the wedge and ring K are raised, and the fangs E F kept open, as in Fig. 2. When the rods come completely down, the open fangs descend over the top of the tool H, and on being quickly lifted, the pressure on the piston D is reversed; the wedge and ring K are pressed down, and the fangs E F are closed, as in Fig. 1, embrace the tool firmly, and lift it with the rods; opening again to allow its fall, when after being lifted as high as may be required, the motion of the rods is reversed, and the pressure once more thrown upon the under surface of the piston D.

Chisels of any required form may be screwed into the tool H; either to cut away the whole material of the bore-hole, or to leave a solid central core N N.

When these solid cores are required, they are extracted by the tools shown in Figs. 3, 4, 5, and 6, Plates 22 and 23.

The first tool employed, M, Figs. 3, 4, and 5, is a crown borer, which being armed with 5 or more chisels, shown in Fig. 8, makes by percussion as already described, a circular cut to the required depth. This crown borer is then removed, and the second tool, O O, Fig. 6, lowered to the bottom of the core thus formed, and the curved teeth P P slide down the surface of the core. An interior cylinder, R R, previously suspended by a cord, is then lowered, so as to press the teeth inwards; a few short strokes are given to the rods, by which the teeth groove themselves into the core, and then by a sudden jerk the core is detached and brought carefully to the surface.

The particulars of several cases in which the improved system of boring has been employed are given in the following Appendix.

APPENDIX No. 1.

Abstract of Registers of Borings on Kind's system.

Localities.	Diameter of Bore.	Depth in Yards.	Time in Days of 12 hours.	Cost of labour per yard.	Cost of the Boring.	Nature of the Rocks.	Observations.
	Inches.	Yards.	Days.	£ s. d.	£ s.		
At Montmoret, Jura, No. 1	12	164	84	0 19 8	160 10	Shifting sand and gravel 33 yds., lias marls 43 yds., gypsums 66 yds., saliferous 22 yds.	Without cost of plant and carriage of tools, &c.
Do. No. 2	do.	185	112	1 2 0	203 12	Do.	
Do. No. 3	do.	309	in progress.				
At Stiring, Moselle, No. 1	do.	327	354	0 19 1	311 11	N. red sandstone 88 yds., carbfs. grits & shales 131 yds., coal measures 108 yds.	
Do. No. 2	do.	355	422	1 0 11	372 5	Do.	
Do. No. 3	do.	295	330	0 19 8	289 11	Do.	
Do. No. 4	48½	120	216	1 4 4	146 0	Do.	Employing a small engine and attendant.
At Guines, Pas de Calais	12	263	86	1 1 9	285 17	White chalk 100 yds., hard grey chalk 163 yds.	
At Vizernes Do.	12	159	37	1 0 7	164 0		
Boring 764 yards deep.			Months.				
At Mondorff, Grand Duchy of Luxembourg { by old system	12	371	37	5 1 0	1873 0	Chalk 46 yds., white grit 14 yds., keuper chalk and gypsum 86 yds.	Without cost of plant, but including tubing to 295 yds.
{ by new system	8 and 5 at bottom.	393	14	2 2 0	829 0	Gypsum 35 yds., red marls 87 yds., quartz grit and red sandstone 292 yds.	

APPENDIX No. 2.

Abstract of Register of Boring on Kind's system at Kreutsberg, near Forbach (Moselle).

Diameter of Bore-hole 11·8 inches.

DATE.	Time in Days of 12 hours.	Depth bored.	Mean depth bored per 12 hours.	Total depth of the boring.	NATURE OF GROUND.	REMARKS.
1852.	Days.	Yards.	Yards.	Yards.		
May 1st to May 11th,	...	7·63	.....	... ..	New Red Sandstone,.....	
June 1st ,, June 4th,	3	3·20	1·07	10·83	.....	
,, 4th ,, ,, 17th,	24	42·14	1·75	52·97	.....	
,, 17th ,, ,, 20th,	6	13·53	2·26	66·50	....	
,, 20th ,, ,, 29th,	17	36·40	2·26	104 90	....	
,, 29th ,, July 26th,	50	63·79	1·27	168·69	....	
July 26th ,, Aug. 11th,	29	30·65	1·06	199 34	. .....	
Aug. 11th ,, ,, 12th,	3	3·25	.....	202·59	Hard Blue Sandstone, ...	
,, 12th ,, ,, 19th,	13	3·36	.....	205·95	Red Sandstone, ...	The Instrument not acting well.
,, 19th ,, ,, 21st,	4	.....	.....	.....	Alternating with Shale, ..	Boring with Diamond Tool.
,, 21st ,, Sept. 7th,	31	10 63	0·34	216·68	.....	
Sept. 7th ,, ,, 11th,	8	.....	.....	.....	.....	Cleaning out the hole.
,, 11th ,, ,, 17th,	12	2·66	.....	219 25	....	Two pieces of the chisel left at bottom of hole, and afterwards five pieces.
,, 17th ,, Oct. 5th,	32	0·33	.....	219·58	... .	In consequence of not succeeding in raising these pieces, determined to bore forward. [& Sheds.
5th,	1	.....	.....	.....	.....	A storm overturned and destroyed the Bore-house
Oct. 5th ,, ,, 20th,	15	.. ..	.....	.....	....	Re-erecting Bore-house, &c.—doing repairs.
,, 20th ,, ,, 23rd,	7	.....	.....	... ..	....	With Diamond Tool.
,, 24th ,, Nov. 2nd,	16	7·54	0·47	227·12	....	
Nov. 2nd ,, ,, 16th,	25	19·12	0·76	240·24	Grey Sandstone, with Red Clay,	
,, 16th ,, ,, 28th,	23	14·38	0·62	260 62	Coal Shale,..... .	
,, 28th ,, Dec. 8th,	20	10·49	0·52	271·11	Sandstone, ...	
Dec. 8th ,, ,, 25th,	34	21·72	0 64	292·83	Shale, ...	
,, 26th ,, ,, 31st,	11	3·13	0·29	295·96	Sandstone, ...	
1853.						
Jan. 1st to Jan. 2nd,	4	1·93	0·48	297·89	Shale, ...	
,, 2nd ,, ,, 9th,	14	6·01	0·42	303·90	Sandstone, ...	
,, 9th ,, Feb. 25th,	87	29·86	0·34	333·76	Shale, ...	
Feb. 25th ,, Mar. 1st,	1	0·55	0.55	334·31	Coal, ...	Bored a "Core."
Mar. 1st ,, .. 2nd.	1	0 46	0·46	334·77	Shale, ...	

(*Kreutsberg, near Forbach, Moselle.*)

TABLE OF MONTHLY COST OF BORING ON KIND'S SYSTEM.

Month.	Depth Bored.	Disbursements.			Division of Labour Expenses.				Entire cost per Yard, each Month (see note). (3)	Entire cost per Yard for each 100 Yards.
		Total.	Plant. (1)	Labour.	Borers	Smiths	Carpentrs	Sundries.		
1852.	Yards.	£	£	£	£	£	£	£	Shillings.	Shillings.
May	7·63	124·18	98·64	25·53	2·03	..	8·19	15·21	....	First 100 Yards. 25·99
June	98·99	193·77	134·03	59·74	47·85	3·38	3·18	5·31	25·99	
July	71·75	114·38	47·40	66·98	51·31	4·14	0·28	11·25	28·77	Second 100 Yards 43·50
August....	35·77	109·02	50·56	58·46	49·02	3·88	2·12	3·44	43·39	
Sept. (2)	5·22	55·98	....	55·98	45·77	3·94	0 11	6·16	232·54	
Oct. (2)	6·69	61·36	12·52	48·84	31·74	2·30	5·54	9·25	161·25	Third 100 Yards 59·15
November..	38·27	65·24	3·38	61·86	51·58	3·74	..	6·53	43·70	
December..	32·65	32·73	7·85	74·87	65·20	3·75	0·19	5·74	57·03	
	296·97	806·65	354·38	452·26	344·50	25·13	19·61	62·91	41·06	

Note 1.—This outlay in Plant includes the first cost of rods, tools, &c., with the erection and material of the Borehouse, Smith's Shop, &c., at the surface.

„ 2.—Unusual accidents occurred in these months, including a storm (Oct. 5th); see Appendix No. 2.

Excluding these two months, in the total amounts 11·91 yards are deducted from the depth, and £104·82 from the labour cost, to give a fair total result, or 285 yards bored for £347.

„ 3.—These costs per yard are calculated with an allowance of 50 per cent. for depreciation in the value of the Plant.

Mr. Blackwell exhibited two specimens of the solid cores that had been cut out and raised by the apparatus; one cylindrical piece of salt rock, 5½ inches diameter and 12 inches long, from the Montmoret Salt Mines, in the South of France, at about 200 yards depth, broken off square at the ends; the other specimen was hard shale rock, from the coal measures, 7½ inches diameter and 12 inches length, with the ends sloped off at an angle of about 45°.

The Chairman remarked that the specimens were very regular in form, and showed great perfection in the action of the tools; it appeared an excellent plan for examining strata, and must prove an important advantage in preventing useless outlay in sinking shafts in many cases, by the information afforded of the actual dip as well as formation of the strata.

Mr. McConnell thought the operation was very complete in bringing up such large and regular specimens, and the means of measuring the dip of the strata would be very serviceable if the accuracy could be relied on, and the expense of the apparatus was not too great. He inquired what was the cost of the whole apparatus?

Mr. Blackwell said he was not able to state the particulars of the actual cost of the apparatus, but the total expense of boring was less with this plan than with the ordinary mode, although a larger bore-hole was obtained; instead of the strong wrought-iron rods required in the ordinary plan when boring to a great depth, on account of the great strain and jar on the rods when they fell all together with the chisel, there were only 3-inch wood rods used in the new plan, as they were not subjected to any strain besides the lifting.

The Chairman asked what diameter of bore-hole was usually accomplished?

Mr. Blackwell replied that in the new plan the hole was bored 10 or 12 inches in diameter, but many of the ordinary bore-holes were only 3 or 4 inches in diameter, except where the strata passed through required telescope tubing, wanting a larger bore to commence with.

The Chairman inquired whether any difficulty was found in boring through the coal measures by the new process, from the various hard strata to be passed through? and whether the tool could be changed, if required, on coming to softer measures, to take out the whole diameter at once without leaving a core?

Mr. Blackwell said the ordinary tool was best in boring through the softer strata, when samples were not desired, and it could be readily substituted for the other tool. There was no difficulty in boring through the coal, and in most strata the process was comparatively rapid; the boring in rock made slow progress, but with a heavy chisel and the blow of a 10 or 15 feet fall, the hardest rock could be got through, and any form or weight of chisel could be readily applied.

Mr. Lloyd asked whether the new plan of boring had been tried in England?

Mr. Blackwell replied that a trial had not yet been made of it in this country, though it had been in extensive use for some time

on the continent; but he understood that Mr. Wall, in London, had made arrangements for introducing the plan and granting licenses for its use.

Mr. SIEMENS observed that he was acquainted with the invention, and had seen the apparatus at work in several places in France for salt works. The process was very successful, and the work was accomplished with great precision and regularity; he had seen many specimens taken out such as those now exhibited, and the particulars and inclination of the strata were ascertained with great accuracy. The process was considerably superior in quickness and economy to the ordinary mode of boring, and the average cost of deep borings he understood was not more than one half; there were three bore-holes, of about 400 yards depth each, completed in two years, and without a single accident.

Mr. COWPER inquired how the crushed portions of the material were got out of the bore-hole, as the solid pieces only could be drawn out by the tool?

Mr. BLACKWELL said there was often found to be sufficient water rising in the hole to wash out the crushed material, otherwise water was passed into the hole in a stream sufficient for the purpose; if necessary a scoop could be employed as in ordinary boring, but this was not generally requisite.

Mr. MCCONNELL observed that it was an important object to ascertain accurately both the direction of the dip and the angle of inclination of the strata; and he inquired how the rods were insured against being twisted round whilst they were drawn up, so as to alter the original direction of the sample piece brought up? and also whether there would not be some risk of the bore-hole getting gradually inclined at the lower part from the original vertical position when the strata were much dipping and the hole happened to be rather harder on one side, which would cause an error in the measurement of the inclination of strata from the sample brought up?

Mr. BLACKWELL replied that the rods were effectually prevented from twisting by passing through a fixed guide at top; the whole process required more care than the ordinary boring when the dip of the strata had to be measured, but no difficulty was found in get-

ting correct results by taking the average of the several specimens, as any errors were then practically neutralised, and the actual dip of the strata would not change perceptibly in a distance sufficient to afford a correct average result. He thought the heavy tool falling freely from a considerable height at each blow in cutting out the hole, would always prevent any material deviation taking place from the vertical direction.

The CHAIRMAN said he thought it was a very ingenious improvement on the ordinary process of boring, and likely to prove of much advantage, and he hoped that Mr. Blackwell would soon have an opportunity of testing its merits by an application in this country.

A vote of thanks was then passed to Mr. Blackwell for his communication.

The following paper, by Mr. William Fairbairn, of Manchester, was then read :—

DESCRIPTION OF AN IMPROVED STEAM TRAVELLING CRANE.

The economy of manual labour in working Travelling Cranes is a subject of great importance to the builder and contractor, for heavy works, and much attention has been given to this subject for several years. Steam power has been employed for some time for the lifting and removal of heavy weights, and the amount of saving in wages effected by a Steam Travelling Crane, compared with the ordinary hand labour machine, has been sufficiently proved during the last four years.

The Crane which is the subject of this paper, the construction of Messrs. Dunn, Hattersley, and Co., of Manchester, closely resembles the general appearance of the ordinary Travelling Cranes used by masons and contractors, as shown by the drawings, Plates 24 and 25. The longitudinal way, transverse carriage, and crab, are arranged in the usual manner. The steam engine and boiler with its driving-gear is supported upon a platform at one extremity of the transverse carriage, being fixed thereto, and travelling with it, in a longitudinal direction, whenever so required.

The advantages sought by this Crane are, that the steam power travels with the traversing carriage, and does not require any longitudinal shafts or bearings, which is the case when a fixed engine is employed; the lubrication and friction of the longitudinal shafting being also saved. It was found from the great length of the longitudinal travel in the remarkably extensive works for the viaducts and bridges of the Grand Trunk Railway of Canada, that the introduction of such modes of driving was too expensive. The saving of these shafts and bearings in the first cost was not the only consideration, the wear and tear and lubrication being a further source of expense, and the repairs very inconvenient.

The Steam Travelling Crane shown in the accompanying drawings, Plates 24 and 25, was designed for the construction of the above works, for the contractors, Messrs. Peto, Brassey, and Betts. A pair of small direct-acting horizontal high-pressure steam engines A A are secured to the two main timbers B B of the traversing carriage. The boiler C is constructed for burning wood; the tubes are made of solid copper, without seam or joint, so that the acid from the wood cannot corrode them.

The engine and boiler with the driving-gear are protected from the weather by a cabin D D constructed of light framework, and covered with a corrugated iron roof. The power of the engine is transmitted by a spur-pinion E upon the middle of the crank shaft, through a spur wheel placed on the horizontal main driving-shaft F, which communicates the motion for hoisting, lowering, traversing and moving the crane longitudinally. Each motion can be used independently of either of the others, or simultaneously, when required. The communication of the power to the various motions is effected by the three sets of mitre-wheels upon the main shaft, which are engaged or disengaged at pleasure, by means of three handles, G, H, I, that move the sliding clutch-boxes as required by the attendant. Three mitre-wheels are furnished to each motion, so that whilst the engine revolves continually in one direction, the reversing of any motion can be effected by the intermediate wheels, as in the ordinary manner.

The motion for moving the carriage longitudinally, is conveyed through the wheels at I, at the extremity of the driving shaft furthest from the boiler. The middle one of the three handles H engages or

disengages the motion K for hoisting and lowering; and the handle G next to the boiler belongs to the motion L for traversing the crab with its weight. The arrangement for moving the crane longitudinally by means of spur-gearing driving the travelling wheels T T, is similar to the plan adopted to a hand travelling crane. The travelling wheels run upon wheels M M, which are fixed at 54 feet gauge, centre to centre.

The hoisting and lowering motion is transmitted to the chain barrel K of the crab, by means of an endless chain N which is placed in the longitudinal direction of the traversing carriage, and is driven by a pulley fixed upon the counter-shaft O, parallel to the main shaft; the motion is communicated by a pair of mitre-wheels through the short intermediate shaft at right angles. This endless chain is connected to a pair of mitre wheels fixed at the lower end of the crab carriage, which give motion to a worm wheel, the latter being keyed upon the chain barrel.

The transverse motion of the crab is obtained by another chain P, placed in a parallel position on the opposite side of the main timbers of the traverser carriage; this chain is attached to the four-wheeled crab, and passes over a pulley on the axis of the worm-wheel L, which is driven by the bevel gear.

An additional handle R is provided for the purpose of throwing out of gear the chain N of the hoisting motion, by means of the clutch-box U, at the time of the transverse motion of the crab, and the chain N then runs with the crab, the pulley at U turning loose on the shaft.

A simple apparatus for adjusting the requisite tension of these chains is provided at the furthest extremity of the two main timbers of the traversing carriage, at the opposite end to the engine, consisting of a tightening pulley S S sliding in grooves, and drawn back by a screw.

This Crane is constructed to lift at the rate of 6 feet per minute. The longitudinal motion works at the rate of 30 feet per minute, and the transverse motion at the rate of 20 feet per minute. The engines are 6-horse power collectively.

The motions can be worked altogether or separately, as desired; and the clutch-box levers are so arranged that the man in attendance can work all the motions from one place.

Mr. DUNN exhibited a working model of the travelling crane, and showed the different motions in operation; he observed that it was similar in principle to the ordinary travelling cranes, with some improvements in the details; and the peculiarity was the addition of the portable engine, to adapt the crane to a more extended distance of traverse, where a continuous shaft from a fixed engine would be impracticable.

The CHAIRMAN inquired what was the extreme distance that the crane had to travel?

Mr. DUNN said it was intended to work to a distance of $\frac{3}{4}$ mile by extending the framing and traversing rails; the first crane was completed but not yet at work; it was intended for setting the stones of the piers in the Great St. Lawrence bridge, and several more were being constructed.

Mr. COWPER observed that the great length of travel required in that particular case might make such a modification of the usual plan advisable; otherwise the plan of driving by a fixed shaft worked very well to a considerable length. He had employed one of McNicoll and Vernon's travelling cranes for a timber yard with 264 feet length of shafting, and found it work well and quite satisfactorily.

Mr. MCCONNELL asked what was the cost of the new traveller complete with the engine, and what load could be lifted and moved about?

Mr. DUNN said the cost of the whole was £550, including the engine and boiler, but exclusive of the timber work for the frame of the traveller and platform and the shed over the engine, which was not sent out, and would be supplied in Canada; and he thought it would not exceed a total cost of £650 including them. The crane was intended for lifting 10 tons, and moving it into any position; it would take more, but was constructed to take that load in regular work.

The CHAIRMAN inquired what was the additional weight of the engine and boiler? he thought a lighter construction of boiler than the one shown might probably be adopted.

Mr. DUNN replied that the engine and boiler weighed $2\frac{3}{4}$ tons; a pair of cylinders with cranks at right angles was employed to give uniform motion without a fly-wheel, and the boiler was tubular, 2 feet

4 inches diameter, and 8 feet long, with 2-inch copper tubes; the fire-box casing was lined with fire bricks, and had to be adapted for burning green wood, the fire-bricks retaining the heat for the fresh charge.

Mr. LLOYD asked what provision was made for supply of water to the boiler whilst working?

Mr. DUNN replied that a wrought-iron water tank was placed under the engine, the top plate of which formed the bed plate for fixing the cylinders.

Mr. remarked that a great saving would be effected in the expense of men required to do the work, if steam power could be safely applied in such a situation; he thought the wheel flanges seemed hardly sufficient protection to prevent the travelling frame getting off the rails.

Mr. DUNN said that a large double flange was employed, $1\frac{1}{2}$ inch deep, both inside and outside of the travelling wheels, and he did not think there was any risk of running off the rails, from the great weight upon the wheels.

Mr. COWPER thought the saving of time in the work done by steam power would be a much more important consideration than the saving in the cost of the work; and the same power could not be otherwise brought to bear upon the work, as there would not be space for a sufficient number of men to apply their power. The portable steam engine would be very advantageous in this respect, and a timber yard was perhaps the only case where it would not be applicable, on account of risk from fire; though even there, it might be practicable to make it safe. In the construction of the crab he thought the endless screw and worm-wheel for the lifting barrel was rather objectionable, as subject to much wear, and liable to require renewal before very long.

Mr. DUNN said that the screw motion, though subject to more wear than toothed gearing, was generally used for the purpose of lifting, as it was more compact and secure, and it could be readily replaced when worn.

The CHAIRMAN asked Mr. Dunn to communicate the result of the actual working of the crane when it had been some time in use in Canada; and he proposed a vote of thanks to Mr. Dunn, which was passed.

The following paper, by Mr. Thomas Forsyth, of Wolverton, was then read :—

ON A NEW STEAM-ENGINE BOILER.

The object of the Boiler to which this paper refers, is to effect approximately a perfect combustion of the fuel; with avoidance of smoke, and of the escape of unapplied useful heat, a reduced risk of burning from scarcity of water, and less rapid destruction from galvanic action. To obtain good results from fuel in combustion as applied to steam boilers, it is necessary to preserve certain relative proportions between the quantity of consumable gases in the coal, and the quantity of the air supplied; and therefore it follows, that either a uniform quantity of fuel should be constantly in combustion, agreeing with a uniform admission of air, or that the air to be admitted should vary in quantity corresponding to the ever varying quantity of fuel in combustion, as in the case of the ordinary process of hand-firing. Machine-firing has been practised successfully, giving constant uniform quantities of fuel in the furnace, corresponding to constant uniform admissions of air; and if the machinery used in the process can be kept in order, such a process appears complete, where the duty required from the furnace is constant and uniform. This however is the exception rather than the rule, as in most cases the duty is ever varying through a considerable range; it appears therefore desirable to have the means of adaptation by a varying furnace-power to the variation of duty required, as in the hand-firing process, and consequently to have a variable air admission always corresponding to the furnace power, or relative quantities of carbon burned off in given times.

To effect this, it is proposed by the Author to make the grate a weighing machine, lowering and rising according to the weight, that is to say, when a charge of coal is put in the furnace, the grate is thereby depressed, and by the coal gradually burning away the grate is elevated as the weight upon it diminishes. From this weighing machine connections are made to the valves for admission of air to the flue, which open and close by the action of the weight of the coal, thus effecting the necessary variation, but preserving the necessary relative quantities and conditions, and thereby avoiding smoke by obtaining perfect com-

bustion. A series of openings for the admission of air are made on each side of the cylindrical portion of the boiler; each opening being constructed with a ring round it, like a fire-door opening, and faced with a grating, upon which the regulating-slide works. The fire-grate has a fire-brick casing sliding up and down freely with the grate inside the fire-box, which is suspended by spring balances, provided with adjusting screws for the attendant to have the means of correcting, for accumulation of clinker on the bars, wearing away of the fire-brick casing, fire-bars, &c., &c.

The fusing-plug to prevent injury to boiler from scarcity of water, is shown in Fig. 4, Plate 23, and is made of a large brass bolt (in which the fusing metal is soldered), cupped on the fire-side, so as to bring the lower side of the tin or "lead plug" within it, some distance above the water-side of the roof-plate, thus leaving a margin, and allowing the plug to be fused while there is yet sufficient water upon the plates to prevent their being burned, and to drown out the fire after the plug has been fused.

In the writer's experience of many thousand fusing-plugs, he has not found any which could be depended upon, except those that he has constructed and applied according to the above principle.

To prevent the destruction of boilers from galvanic currents, which the writer has many opportunities of observing, he proposes to adopt generally the use of a piece of zinc, in metallic contact with the boiler plates, and to be renewed from time to time as required; this practice he believes has been successfully applied in iron ships, and for other purposes, but not generally used in steam boilers.

To prevent the escape of useful heat, the chimney is made multitubular, and converted into a feed-pipe, receiving its water at the top, and delivering it to the boiler at the bottom, by which the flue temperature at the outlet is reduced even without producing any cooling effect upon the boiler, the spare heat being abstracted for a useful purpose.

In large engineering and other works where many forges and furnaces are in operation, it is proposed to run from a cold-water tank a main or pipe with ball taps, and small tanks to supply the tuyeres of the several forges, &c., with cold water; and as this water becomes heated, to draw it off by a main feed-pipe with a force pump into the tubular chimney

feed-pipe; also to case the chimneys and hoods of the forges with water, for the double purpose of keeping the shop cool in hot weather, and obtaining the waste heat for useful application. The feed-pipe chimney to be provided with a safety valve to prevent it bursting, if at any time the pump be in action when the valve to the boiler is closed.

It has to be observed, with reference to the arrangements for effecting the above objects, that no man with sufficient intelligence and education to understand the rationale of the chemical and mechanical requirements for effecting most perfectly the end in view, can be expected to act long as a stoker, and that stokers are not scientific and philosophical, and therefore processes requiring delicate and frequent manipulation, and careful application of sound judgment on the part of those to whom engine furnaces are generally entrusted, are not likely to succeed for any length of time. The appliances in the present case have therefore been made self-acting, likely to remain in good order, and not requiring nice and frequent manipulation, such as would be troublesome to the stoker.

The CHAIRMAN said that the construction shown of the fusible plug appeared a decided improvement upon the usual make, as there was more certainty in its action, and it would melt before the boiler plate became uncovered. He remarked that in France the principle was carried out still more completely by inserting a plate of fusible metal in the boiler, which would soften and give way when the temperature due to the regulated pressure was exceeded, either by deficiency of water supply or excess of steam pressure. This means of precaution was found very efficient, and was of universal application in France, being made compulsory on the part of the Government under a penalty, all steam boilers being examined annually by Government inspectors, and not allowed to be used unless fitted with one of these safety plates.

Mr. FORSYTH observed that the use of the fusible plate would have a disadvantage in causing the boiler and engine to be entirely stopped whenever the plate was melted by the high temperature, which was liable to occur from accidental causes; and in the case of a stationary engine driving a factory or locomotive engine

with a train, the stoppage would cause great inconvenience and expense. He suggested the use of a small plate, such as a thin plate of tin, only about an inch diameter, fixed like a diaphragm across a short tube attached to the boiler, closing the mouth of the tube steam-tight, but giving way by bursting outwards when the pressure exceeded a certain limit; the engineman would then be warned of the danger by the report, and would readily shut the tube by a cock, preventing any stoppage of the boiler, and fix another safety plate on the mouth of the tube by unscrewing a cap and removing the exploded plate. His idea was to make one part of the boiler weaker than all the rest, so that it might give way first at any regulated pressure, but at the same time to prevent any inconvenience arising from the accident, which would be no more than the explosion of a percussion cap, giving warning to the engineman to arrest the cause of the mischief before reaching a dangerous limit, and providing the means of quickly replacing the exploded part without interfering with the working of the boiler. He thought it preferable to have the pressure-plate and the fusing-plug separate and independent of each other, rather than combined as in the French arrangement.

Mr. CHELLINGWORTH inquired what was the metal of which the French safety-plates were composed, and how they were applied?

The CHAIRMAN said they were made of an alloy of bismuth and other metals in various proportions, so as to give way at different temperatures according to the pressure at which the boiler was to be worked; the plates were all supplied by the Government, and were carefully adjusted by tests for the different pressures required, and stamped accordingly with the regulated pressure; the plates were usually fixed in a frame, or by set screws, like a boiler-plate patch, over a hole about 3 inches square cut in the boiler for the purpose, so that a fresh plate could be put on if the pressure ever got so high as to burst or melt it. This plan appeared to answer the purpose simply and efficiently in preventing explosions, whether from undue pressure of steam or deficiency of water, and it had the advantage of being out of the control of the engineman. He remarked that there had been a great variety of plans invented for consuming the smoke in furnaces, mainly consisting of different modes of regulating or pro-

portioning the supply of air, the continued changes in the fire requiring corresponding alterations in the quantity of air admitted, in order to obtain complete combustion of the fuel and absence of smoke. Many of these inventions, though very ingenious as self-acting contrivances, were not found satisfactory in practical application, from the changes in the condition of the furnace, in the quality of the coal, and in the openness or closeness of the fire bars from clinkers, and from the liability of the apparatus to get out of order; and he feared the plan described would be liable to these objections.

Mr. ADAMS observed that the consumption of the smoke was completely effected in the large steam-engine boilers of Cornwall, without the use of any apparatus for the purpose; he had observed several of them recently, and found they were worked almost entirely free from smoke; and no other means was employed for consuming the smoke but the use of large furnace and flue room, and very careful firing, no waste of fuel being allowed, and the stokers being prevented from letting any smoke appear by the fear of losing their places.

The CHAIRMAN said there was no doubt that with plenty of boiler room, so that the fires need never be forced, it was quite possible to burn the smoke sufficiently without resorting to the use of special apparatus for the purpose, if a sufficient degree of care were taken in the firing; even the consumption of coal in locomotive engines without producing smoke had been effected by Mr. Mc Connell by giving extra fire-box space. In the engines of Cornwall it had to be remarked that the coal used was all Welsh, which gave less smoke, being less bituminous than most coals; but there was no doubt that the consumption of smoke was carried out there very completely by simply directing constant attention and care to the firing; numbers of large engine chimneys were to be seen there whitewashed at the tops, and remaining clean and practically free from smoke, no traces being visible for weeks together.

Mr. COWPER remarked that in a pair of large Cornish boilers he had fixed in London, the smoke was completely consumed when constant care in the firing was enforced; but in that case, the fuel used was nothing but sawdust, burnt upon an ordinary grate with bars very close, and fed very frequently in small quantities. He thought that

if there were the same care bestowed on the ordinary single furnace boilers as on those with special contrivances for the purpose, there would be very little smoke seen, excepting in the cases where the boiler was too small for the work, and then the supply of steam could only be kept up by an extravagant expenditure of fuel, as well as wearing out of the boiler.

The CHAIRMAN proposed a vote of thanks to Mr. Forsyth for his communication, which was passed.

The CHAIRMAN then observed that he wished to call the particular attention of the Members to the importance and value of donations to the Institution of Engineering and Scientific books, to form a good library of reference; and he expressed a hope that all the Members would aid in carrying out this desirable object, by presenting some books or models to the Institution.

The meeting then terminated, and after the meeting Mr. C. William Siemens, of London, exhibited a new instrument, the invention of Fessel, of Cologne, by which the stability of the axis of rotation in a revolving body was illustrated in an ingenious and striking manner. The instrument, named a gyroscope, consisted of a small fly-wheel revolving in a frame, attached by gymbal joints at the end of a supporting rod, which was left free to move in any direction, by passing through a ball and socket joint fixed upon a centre pillar. When the fly-wheel was made to rotate rapidly (by means of a string wound on its axis) in a plane transverse to the supporting rod, but inclined at any angle to it, the fly-wheel maintained itself in whatever inclination it might be placed, although its weight was *unbalanced;* but at the same time the whole apparatus revolved slowly in a horizontal plane, by turning the central ball and socket joint. When a counterpoise weight was attached at the other end of the suspending rod, just sufficient to *balance* the weight of the fly wheel and its frame, the horizontal revolution did not take place; but when a greater weight was attached, so as to *overbalance* the rod, a similar revolution took place in the opposite direction to the former one, the fly-wheel maintaining its level in each case, until the velocity

of the rotation on its axis became considerably diminished, when it gradually sank down to the lowest position if unbalanced, or rose to the highest position if overbalanced. If the suspending rod and fly-wheel frame were made forcibly to revolve horizontally faster than, or in the opposite direction to, the self-assumed motion, by applying a sudden lateral force, great resistance was opposed to this extraneous force, and the result was a sudden fall or rise of the fly-wheel and frame, according to the direction of the force applied.

The instrument was shown in action by Mr. Siemens, and he explained that its original invention had arisen from an investigation into the laws of the stability in the axis of the earth's rotation, upon which M. Fessel had been engaged, that had led to the trial of various experiments in rotating bodies; and the present instrument, although not useful in itself, could not but be interesting and serviceable as an aid in investigating the action in all parts of mechanism in rapid rotation.

SELF CLOSING FURNACE VALVE.

Plate 26.

Fig. 1. *Front Elevation.*

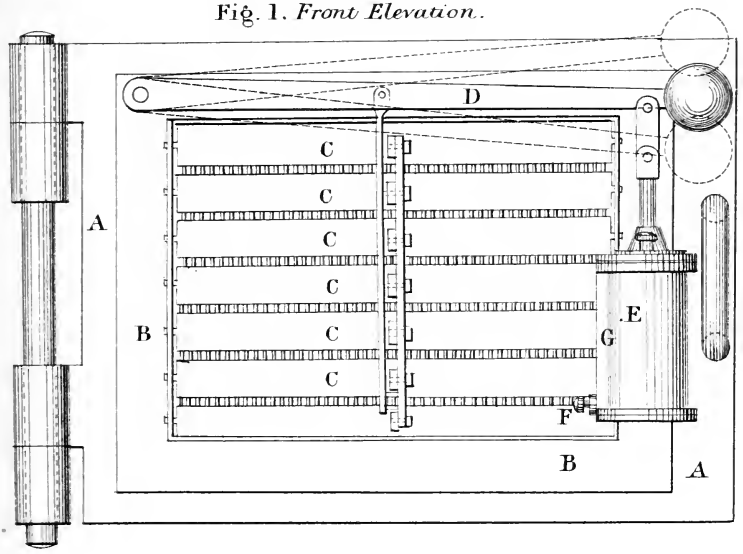
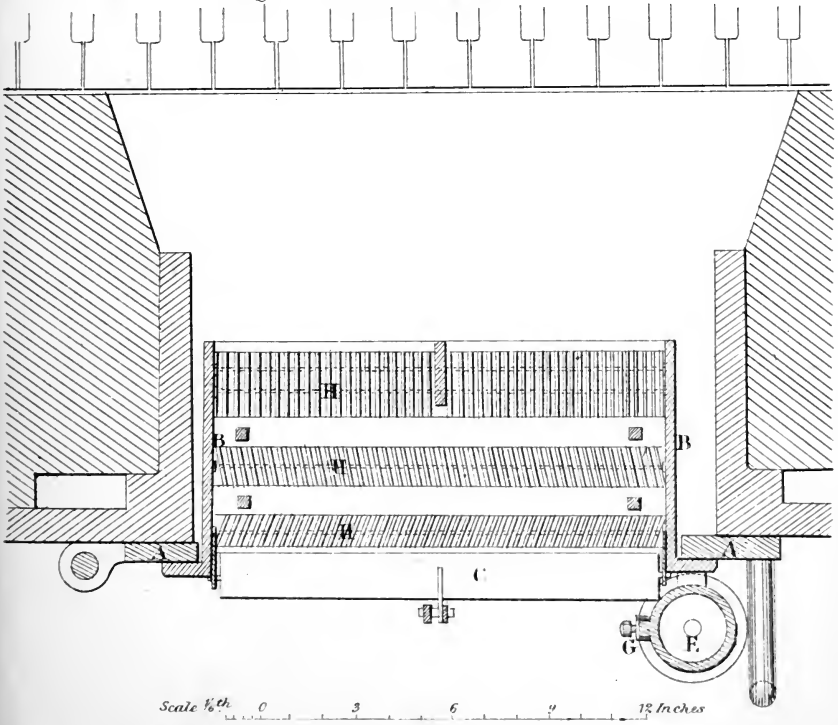


Fig. 2. *Sectional Plan.*



(*Proceedings Inst M E. 1854. Page 111.*)

SELF-CLOSING FURNACE VALVE.

Plate 27

Fig. 3. *Vertical Section*

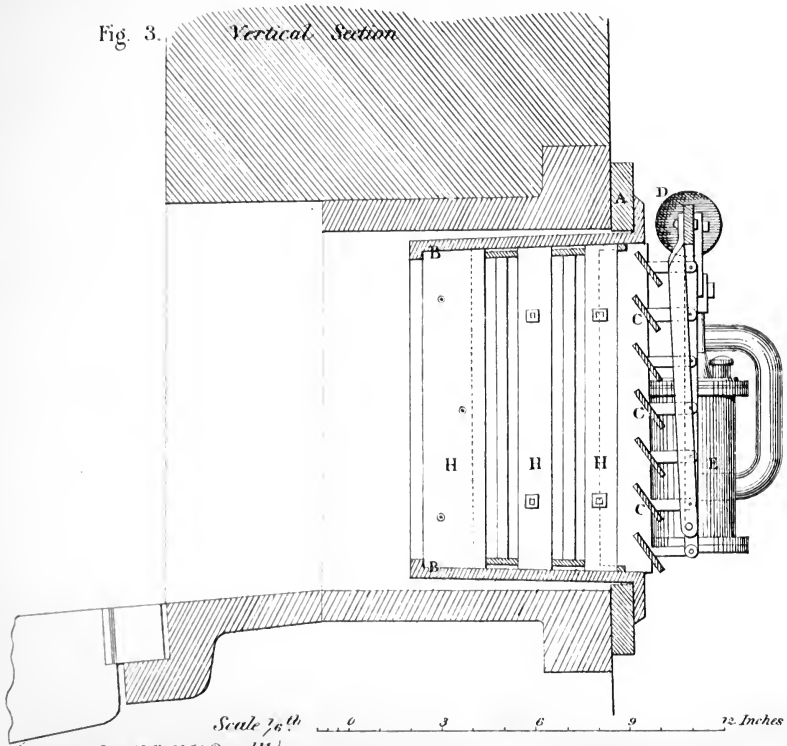


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Fig. 4. *Section of Cylinder*

(Double Scale)

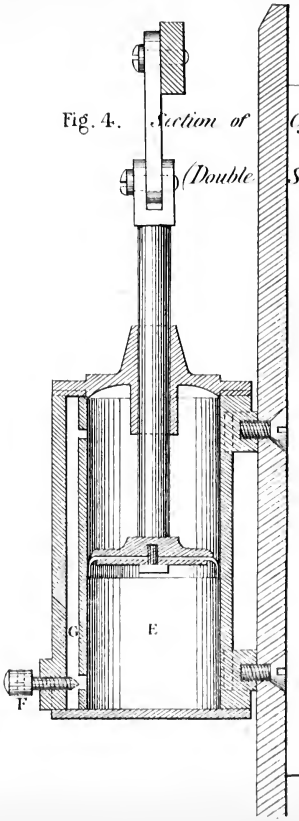


Plate 27

Fig.1. *Section.*

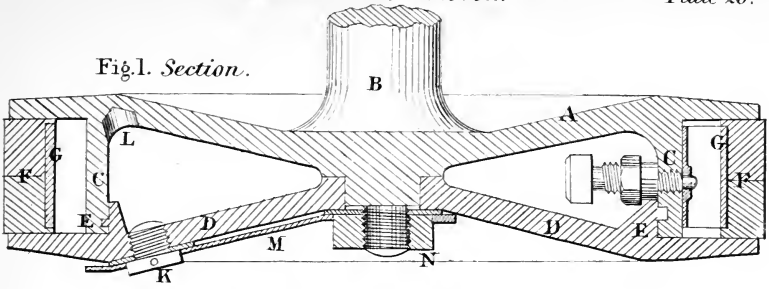


Fig.2. *Elevation of Cover*

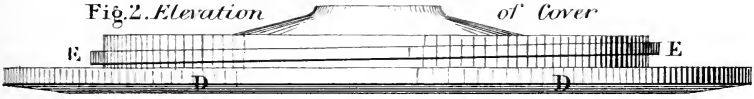


Fig.3. *Plan.*

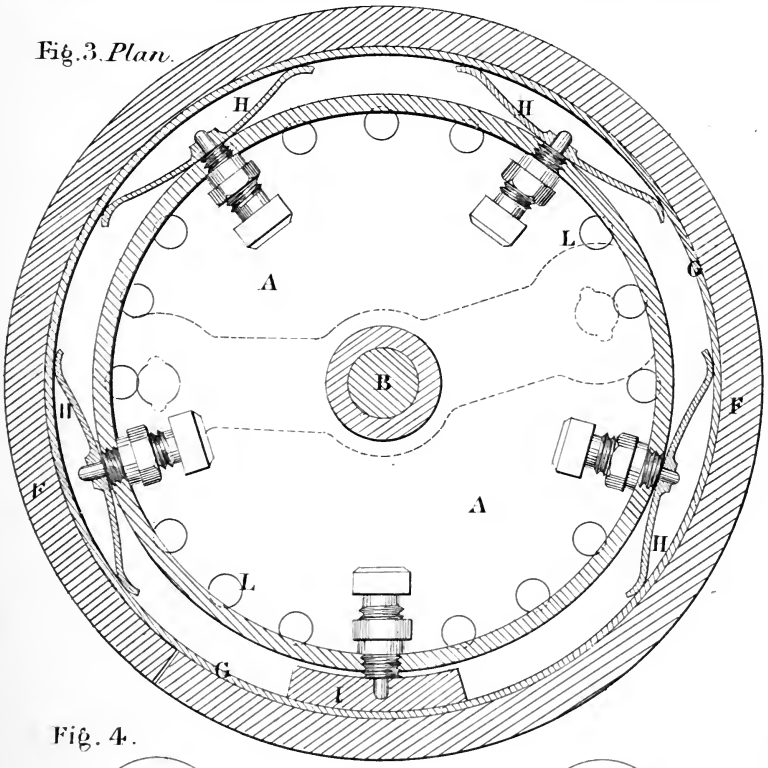
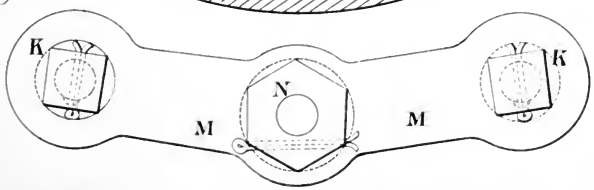


Fig. 4.



Scale 2/9ths 0 3 6 9 12 Inches

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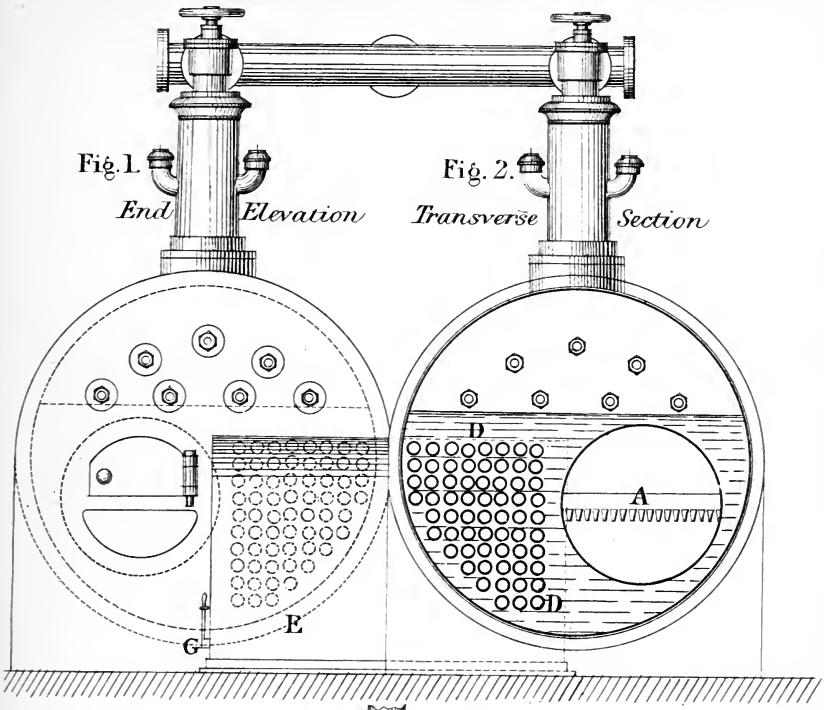
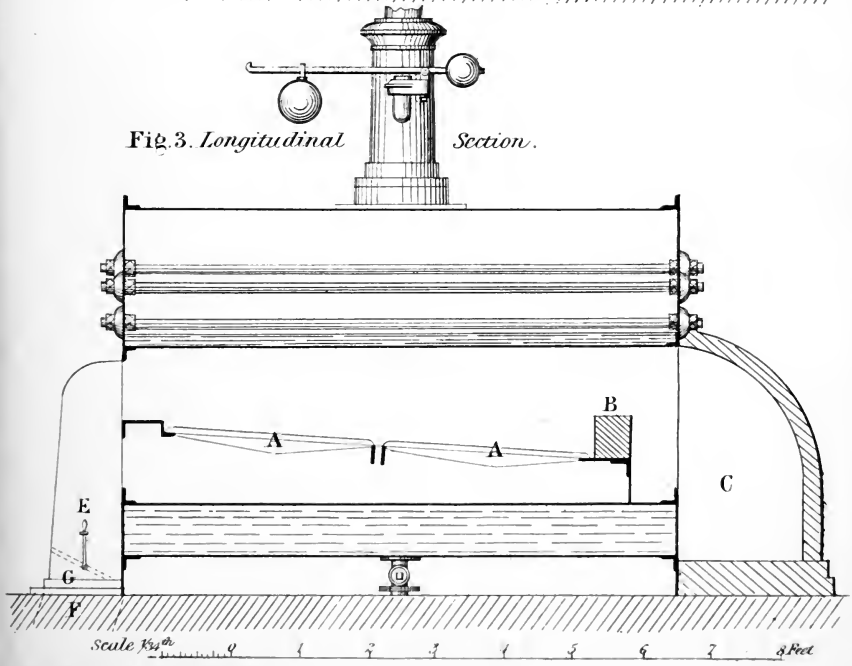
IMPROVED BOILER. *Plate 29.*





(Proceedings Inst. M.E. 1854 Page 123)

Fig. 5. *End Elevation*

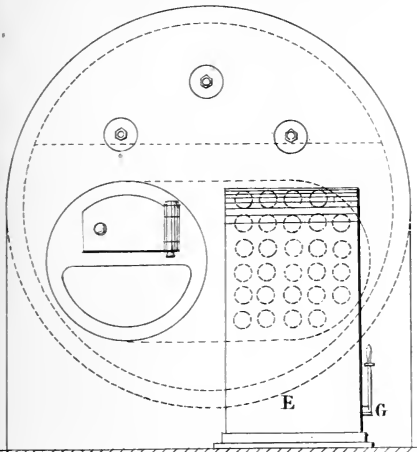


Fig. 6. *Transverse Section.*

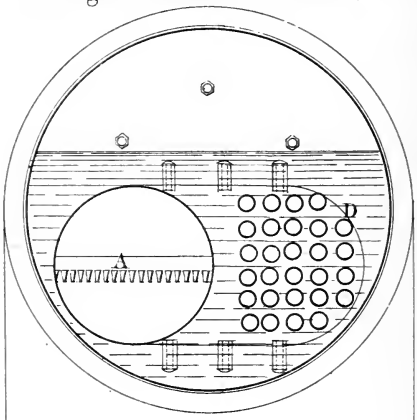
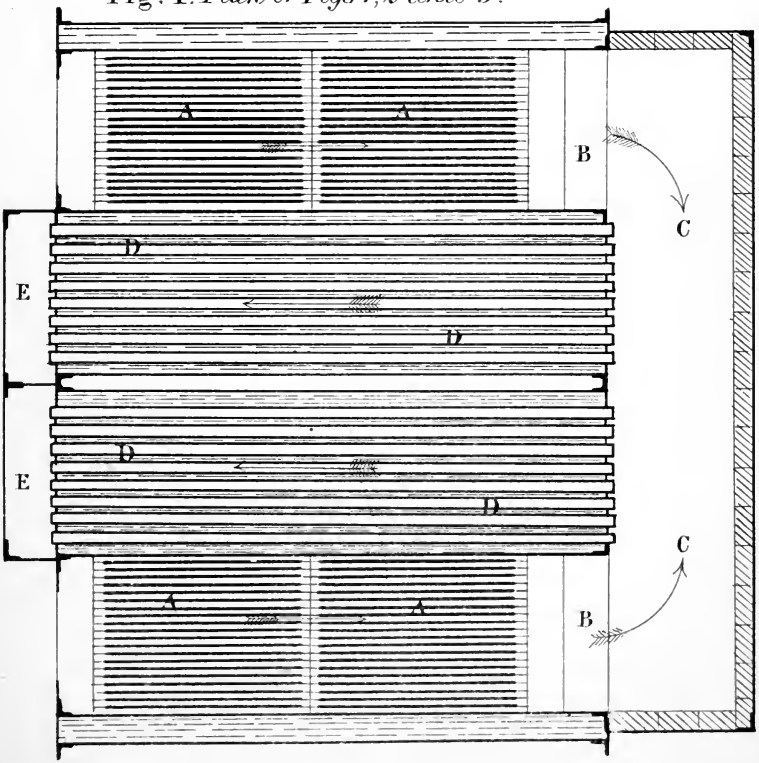


Fig. 4. *Plan of Figs 1, 2 and 3.*



Scale 1/24th ..... 0 1 2 3 4 5 6 7 8 Feet

(Proceedings Inst. ME 1854 Page 123.)

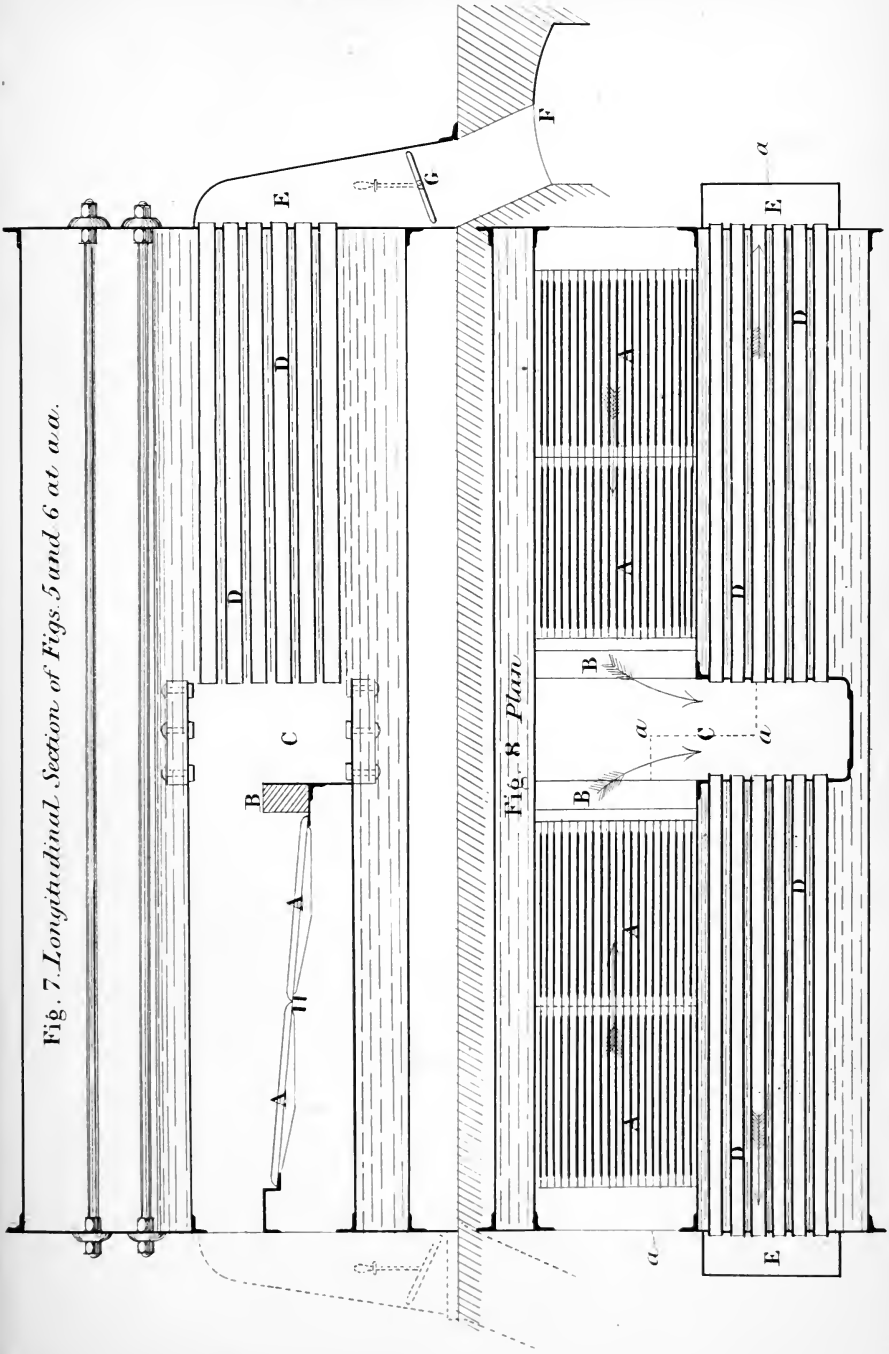


Fig. 7 *Longitudinal Section of Figs. 5 and 6 at a.a.*

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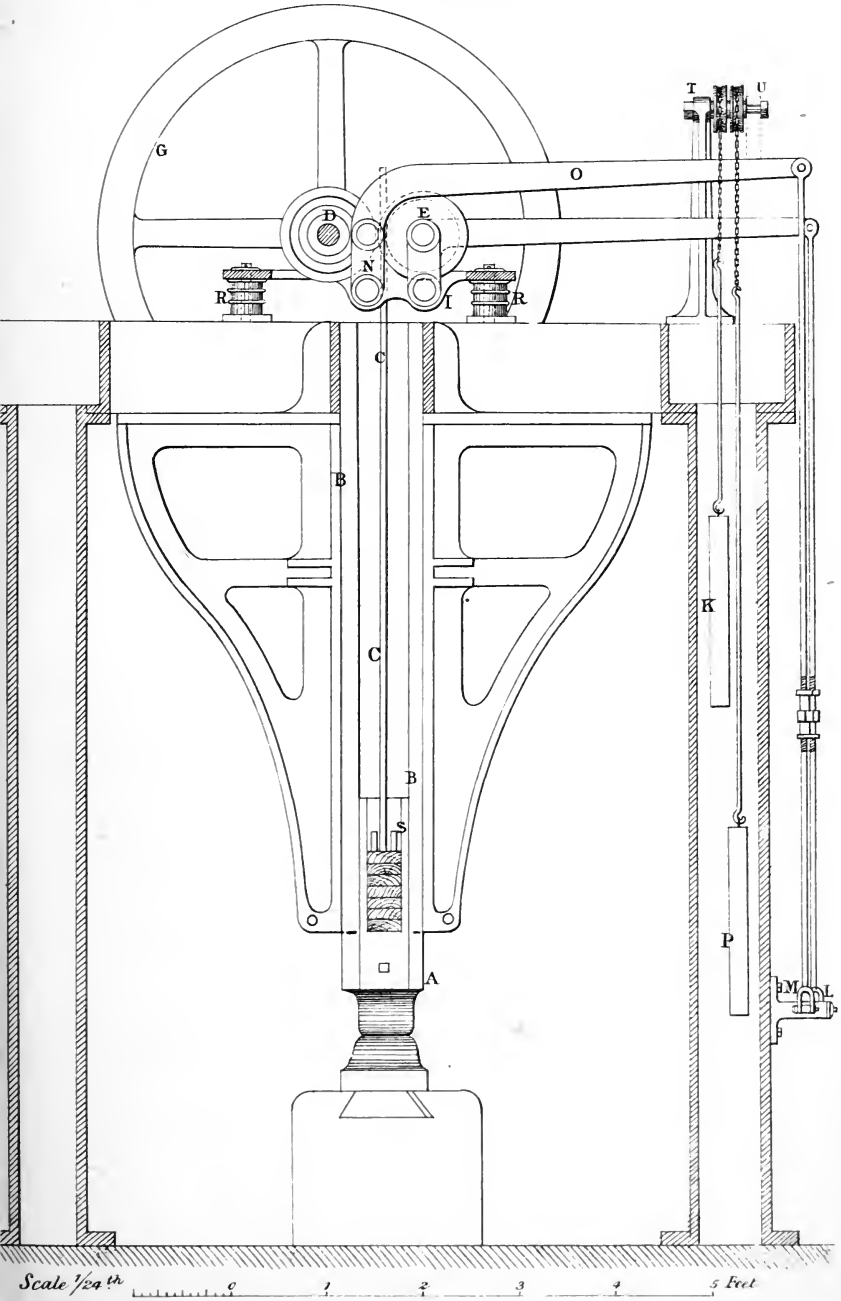
FRICTION HAMMER

Fig. 1. *Elevation*



(Proceedings Inst. M. E. 1854 Page 133)

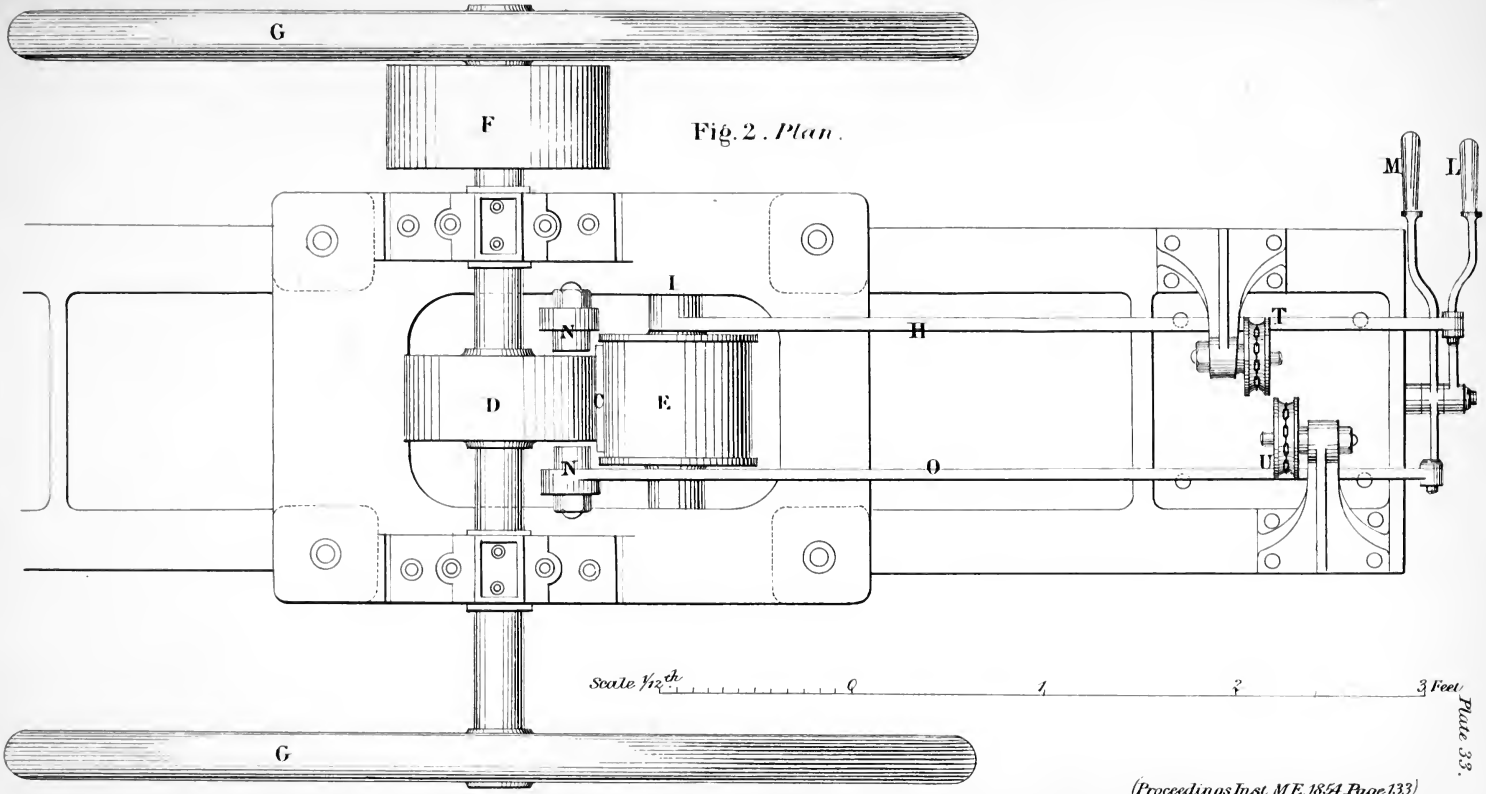


Fig. 2. *Plan.*

Plate 33.

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PROCEEDINGS.

November 1, 1854.

The General Meeting of the Members was held at the house of the Institution, Newhall Street, Birmingham, on Wednesday, November 1st, 1854, William Fairbairn, Esq., F.R.S., President, in the Chair.

The Minutes of the last General Meeting were read and confirmed.

The Chairman announced that according to the rules of the Institution, the President, Vice-Presidents, and five of the Council in rotation would go out of office next year; and that at the present Meeting the Council, &c., were to be nominated for the election at the next Annual Meeting.

The following list of Members was adopted by the Meeting for the nomination at the next Annual Meeting.

PRESIDENT.

William Fairbairn, F.R.S., Manchester.

VICE-PRESIDENTS.

(Six of the number to be elected.)

Samuel H. Blackwell .	Dudley.
John E. Clift . .	Birmingham.
Edward A. Cowper .	London.
Benjamin Fothergill .	Manchester.
James E. McConnell .	Wolverton.
John Penn . . .	London.
Archibald Slate . .	Dudley.
John Scott Russell .	London.
Joseph Whitworth .	Manchester.

COUNCIL.

(Five of the number to be elected.)

George Downing	Smethwick.
John Henderson	Birmingham.
Edward Jones	Liverpool.
Matthew Kirtley	Derby.
James Kitson	Leeds.
Henry Maudslay	London.
Robert B. Preston	Liverpool.
John Ramsbottom	Manchester.
Charles W. Siemens	London.
Henry Wright	Birmingham.

The Chairman observed that as the Members had proposed him again for election as President of the Institution, he should be happy to serve in that capacity for another year, and would devote his best exertions to promote the interests of the Institution; but he quite agreed with the opinion that had been expressed by his predecessor, that it would be the best arrangement and most advantageous to the Institution, for the President to be periodically changed, and not to continue longer than two years in office.

The Chairman announced that the ballot papers had been opened by the Committee appointed for the purpose, and the following new members were duly elected :—

Members.

Peter Duckworth Bennett, Westbromwich.
Frederick Joseph Bramwell, London.
Thomas Dunn, Manchester.
John Fernie, Derby.
James Gascoigne Lynde, London.
Francis Edgar Martineau, Birmingham.
George Smith, Dudley.
Thomas Walker, Birmingham.

The following Paper, by Mr. John E. Hodgkin, of Birmingham, was then read :—

ON PRIDEAUX'S SELF-CLOSING VALVE, FOR PREVENTING SMOKE IN STEAM-BOILER AND OTHER FURNACES.

The object of the apparatus described in the present paper, the invention of Mr. T. S. Prideaux, of London, is to obtain the combustion of the smoke in the furnaces of steam-engine boilers, brewers' coppers, and other close furnaces, by means that can be readily adjusted to all variations of circumstances, so as to insure the complete prevention of smoke, with economy of fuel; and at the same time to effect these results without interfering with the steam-generating power of the boiler, or requiring troublesome attention to work and keep it in order, and by means admitting of convenient and economical application to existing furnaces.

The mode employed, is the admission of the extra supply of air that is required solely for the combustion of the smoke, through a self-closing valve, which regulates the admission continuously in a diminishing rate, according to the quantity required by the state of the fuel, and stops it entirely, when no further extra supply of air is needed; this occurs when all the gas is distilled out of the charge of coal, usually in from three to six minutes after each time of firing.

This air-valve is placed in the fire-door, causing the air admitted to pass over the whole of the burning fuel before entering the flue, for the purpose of obtaining the most complete mixture and combination of the air with the gases. The valve is made with a series of thin metal plates on the inside, which serve to heat the air on entering, and at the same time to keep cool the outside of the door and the valve.

The construction of the apparatus is shown in the drawings in Plates 26 and 27, which represent the valve as used for the furnaces of steam-engine boilers. Fig. 1 is a front view of the valve fixed in the fire-door; Fig. 2, a sectional plan of the valve and door; and Fig. 3, a transverse section at the centre.

The fire-door AA, has a large rectangular opening in the centre, into which the air-valve is fitted, the door consisting only of a cast-iron frame, to which the casing BB, of the valve is secured by a flange.

The opening in front is covered by a series of thin wrought-iron shutters CC, turning on end pins like a Venetian blind, and regulating or entirely closing the opening for admission of air through the door. These shutters, forming the air-valve, are opened by lifting the lever D, at the time of shutting the fire-door after each firing, and their gradual self-closing is effected by means of the regulating cylinder E, which is a simple form of cataract.

This is shown in Fig. 4, and consists of a brass cylinder 2 inches diameter, and 5 inches stroke, with a solid piston, which is connected to the end of the lever D.

The cylinder is filled with water, and when the lever is lifted the piston is raised with it, and is then checked in descending, by the water below the piston, which is expelled gradually through the small side passage G, communicating with the top of the cylinder, by the pressure of the weight of the lever D, which is thus gradually lowered, diminishing regularly the opening for admission of air through the valve, until it is quite closed. The time of closing the valve is regulated by a small screw-plug F, in the side passage, affording the means of an accurate adjustment, so as to close regularly in any number of minutes that may be required.

The piston of the cylinder E, consists simply of a cupped disc of vulcanized india-rubber, held between two plates, which collapses when the piston is drawn up, allowing the water to pass freely, but fits tight during the down stroke.

The air on entering through the valve passes between three sets of thin wrought-iron plates HH, set edgeways, with narrow air-spaces between, which serve to warm the air on entering, and at the same time to protect the outer shutters and regulating cylinder from getting heated. The first two rows of plates are inclined a little in opposite directions, so as to cut off the direct radiation of heat from the fire; this arrangement is found to act effectively in all cases in preventing the outside of the door from getting heated, and it becomes only slightly warmed, even when the air-valve has been shut for some time just before the period of firing, when the inside of the inner set of plates towards the fire has become nearly red-hot.

The principal object in this apparatus is, to admit an extra

supply of air at the time of supplying fresh fuel, in sufficient quantity to consume the smoke, by combining with the gases distilled from the fresh fuel, and to diminish gradually the extra supply of air, in proportion as these gases diminish in quantity, stopping it altogether as soon as the fresh coal has become sufficiently coked to burn in the ordinary furnace without smoke. The importance of an arrangement for this purpose arises from the circumstance, that in order to consume the smoke entirely, when fresh coal is added, a supply of air is required of nearly double the quantity that is sufficient for the perfect combustion of the coal after its gaseous products have been mostly driven off; consequently, unless the supply of air is varied to that extent during the burning off of each separate charge, there must be either *too small* a supply of air at first firing, causing the production of smoke and waste of fuel from imperfect combustion, or *too great* a supply of air during the remainder of the time, causing waste of fuel by the useless air carrying off heat, and a cooling effect on the boiler surface exposed to its influence.

With the present apparatus, all that has to be done by the fireman, is to lift the lever on shutting the door after each time of firing; the self-closing valve then provides for the rest of the process. This raising of the lever might even be made self-acting on the closing of the door, but that is probably not advisable, as the valve would then act whenever the door was opened, simply to examine or rake the fire, and there has not been found any objection or difficulty in working the valve regularly by hand, as the operation is so simple as soon to become habitual, the stoker having also an inducement to keep the valve in action, on account of the cool temperature that is maintained in the stoke-hole. Instead of becoming nearly, or quite red-hot, as the fire-doors not unfrequently do on the ordinary plan, the doors having the present valve fixed in them, never, with good furnace arrangements, get perceptibly warmer on the outside than the external air. This is an advantage of considerable importance in confined situations, and more particularly in the case of marine boilers, where the great heat of the stoke-hole is very objectionable, and impairs the efficiency and health of the firemen.

The size of the air-valve is regulated by the area of fire-grate, and it is generally made 1-12th of the area, or 12 square inches of air-valve for each square foot of fire grate; in the case of Cornish boilers, or boilers in which the fire is surrounded by water spaces, about half the above area being open space. In brick furnaces a larger area of air-valve is employed, amounting to 16 or 18 square inches per square foot of fire-grate, because the temperature of the fire brick walls of the furnace being much higher than that of the surrounding boiler-plate in the former case, the distillation of the gas from each fresh charge of coal is carried on so much more rapidly, and a larger supply of air has consequently to be admitted at first, to obtain complete combustion of the smoke. For the same reason the valve has to be adjusted to close sooner in the second case, so as to admit only the same total quantity of air in each case. Also the closing of the valve is adjusted to the usual regular rate of charging the fire as to quantity of coal, and when this is varied by having to fire more or less heavily, the valve is readily adjusted accordingly, by opening or closing the regulating screw a little; or if the alteration in rate of firing be only temporary, it is readily allowed for by raising the valve a second time after it has partially descended, or by not raising the lever to its highest position.

The consumption of the smoke is completely under the control of the fireman with the use of this valve, and he can readily adjust it, so as to insure the smoke being practically consumed under all circumstances of regular work, except during the actual time of firing, when the door is open, and the cooling effects of the excessive quantity of cold air admitted, cause a small portion of the smoke to pass away unconsumed; also at the time of lighting the fire, or getting up a low fire when the temperature is too low at first for maintaining complete combustion of the smoke.

The complete efficiency of the air-valve in consuming the smoke is strongly shown, by leaving the valve closed for a minute or two after firing, when dense black smoke issues from the chimney; and then, in less than half a minute after opening the air-valve, as soon as the current has traversed the length of the flues and chimney, the smoke is suddenly cut off and continues to be invisible. This

has been repeatedly tried with the same success at different furnaces where the valve is applied; and the trial has been repeated once and sometimes twice with the same charge of coal, bringing back suddenly the previous dense black smoke by re-closing the valve, and then as suddenly cutting it off again by re-opening it.

This apparatus has been now in operation for five months, applied to a steam-boiler at the Author's works, in Birmingham, and has proved quite successful; it has been in constant action during the time, and has not required any repair. The only part appearing liable to wear out, is the set of plates next the fire; but these are little exposed to injury if the fuel is kept from actual contact with them, and they can be readily replaced at small cost whenever requiring renewal.

A saving of fuel is expected by the inventor to be effected by the use of this apparatus, from the prevention of waste of fuel in the form of smoke and unconsumed gases, without the admission at any part of the time of useless air to carry off a portion of the heat. This has been confirmed by the results of comparative trials made by the Author, with the boiler at his works, which show a somewhat lower consumption of fuel when the air-valve was used than when it was not in action. This boiler is, however, small, only 10-horse power, and a trial on a more extensive scale would be required to determine the correct proportion of saving in fuel.

In this trial the boiler was worked for four successive periods of three days each, alternately with the air-valve in action during two of the periods, and thrown out of action during the other two; and the fuel consumed (very fine slack) during each of the periods was weighed separately. The work done, and general circumstances, were nearly the same in each case.

The general particulars of this trial are, that during the six days without the valve the consumption of fuel averaged 177 lbs. per hour, being 13,552 lbs. in 76½ hours; and during the six days with the valve in action, the fuel averaged 155 lbs. per hour, being 12,544 lbs. in 81 hours. The result of this trial shows an average saving of 12 *per cent.* by the use of the valve.

This result is only approximate, as there was not the means of regulating the work so as to be exactly the same in both experiments; but it appears to be confirmed by the general results in other places, where the relative consumption has been measured.

The writer has examined the action of this valve in other cases, and found it quite satisfactory and complete in the prevention of smoke, and in keeping the apparatus cool and in good order; and he believes the same successful working has been found in an extensive application that has been now made of this apparatus, both to the boilers of stationary and marine engines, and to other close furnaces, for brewers' coppers, &c.

A specimen of the furnace valves was shown, with the regulating cylinder in action, and a sectional model showing the arrangement of the interior plates.

The CHAIRMAN said he had seen the apparatus in action applied to some steam-engine boilers in London, at the London Docks, and the printing office of the Illustrated News, where he had had an opportunity of making some observations on the operation of the appartus. It certainly cut off the appearance of smoke very efficiently, and it acted promptly in clearing the flues and chimney of the smoke, when put into action, after dense smoke had first been allowed to issue from the chimney by keeping the apparatus shut after coaling. He had seen a similar effect produced in some places, where the consumption of smoke was attended to, by leaving the furnace door a little open, about 1 or $1\frac{1}{2}$ inches, after putting on fresh fuel, so as to admit the extra supply of air required for igniting the gases as they are given off at that time. The apparatus of Mr. Prideaux had however an important practical superiority in accomplishing a definite regulation of the air admitted, according to the necessity for it, and providing for the process being systematically carried on; the plan was very efficiently worked out, and the apparatus was compact and well contrived. It kept in order and performed its work very efficiently, and would doubtless be an advantageous addition to any boiler, however well constructed for burning the smoke, by making the process more complete and certain in its effects.

He inquired of Mr. Prideaux what was the extent to which the plan had been at present practically applied, and how long it had been in use?

Mr. PRIDEAUX replied that there were about 100 at work in different parts of the country, applied to steam-boilers, the greater number of them being in London, and a few others applied to brewers' coppers; some of them had been six months at work, and all of them, he believed, were working quite successfully, and had given complete satisfaction to the parties using them. The whole of those that had been applied, with the exception of two that had received injury, were, he believed, now in constant work, and they had not failed in any way, nor required repair during the time.

The consumption of fuel was not kept account of in most of the cases, but in every case where the coal was measured, a saving of fuel had been admitted, and generally from 10 to 15 per cent., from the use of the apparatus; the saving was found to be greatest in brick furnaces, amounting to about 15 per cent. At one steam-boiler in London, it was stated by the proprietors (Messrs. Lee and Sons, Blackfriars Road), that the weekly consumption of coal was reduced from 5 tons, to 4 tons 5 cwt., by the application of the valve, without any other alteration, the saving amounting to 15 cwt. on a grate of 15 square feet area, or 1 cwt. of coal per foot of grate per week; this result was confirmed by a general comparison of other cases.

Mr. MCCONNELL said, he had made a trial of one of the valves on a steam-boiler at Wolverton, and had found it quite successful in consuming the smoke; the inner ends of the plates had been found, however, to get too hot and burn away, and they had to be removed further out, being at first too near the inner end of the dead-plate, and leaving only 3 inches space from the end, they were removed 7 inches distance. He inquired what rule had been found best for the purpose in practice?

Mr. PRIDEAUX replied that he had always found 2 or 3 inches distance from the end of the dead-plate was sufficient to prevent the plates of the valve from getting burned, if the coal was kept away from actual contact with them; but they would get injured if the burning fuel was allowed to touch them, and to insure this being prevented, a projecting

mouth-piece to carry the fire-door was generally fixed in the cases where the dead-plate was very short. He thought the over-heating of the plates might probably have been caused by the fire being damped and shut up for the night, without the admission of any air during the time through the valve. The only case he had met with of the plates getting very hot, was in the furnace of a brewer's copper, where the fire was shut up a whole night with the damper on, and the valve closed all the time; but in such cases, by fixing the valve a little open it was prevented from getting too hot, or other means might be readily adopted to meet the difficulty. In the regular working the valve was opened about every quarter of an hour, and exposed to the cooling action of the air for about one third the time, which effectually prevented any injury of the plates; and even after five months work, the plates continued as good as when first put in. This was shown in the case of the valves at the London Docks, referred to by the Chairman, which had been in constant work for five months, and still look quite fresh.

Mr. McConnell thought the injury of the plates that he had experienced, might have arisen from shutting down the damper at night, and he would make a further trial; he had certainly found the apparatus very good in working, and intended to employ some more of them. He considered it very ingenious, and well contrived for the purpose.

Mr. Prideaux said, that several parties who had tried one of the valves, were so well satisfied with the results in improving the working of the boilers, as well as consuming the smoke, that they were applying them at their works in the country, where the smoke was not of consequence. In many of the cases in London, there were great difficulties from the confined position of the boilers and deficient draught, several boilers being not unfrequently carried into one small house chimney; the application of the valve had in many instances made a material improvement in the steam-generating power, from the more perfect combustion. In those confined situations the coolness of the fire-door was found a considerable advantage; and this was particularly important in the case of marine boilers, where the heat of the stoke-hole was greatly diminished by the adoption of the valve; in a marine boiler at Portsmouth, where it was tried, when the external air was at

the temperature of 40°, the back of the door was not found to get hotter than 45° during the time the valve was closed between each time of firing.

The CHAIRMAN observed that the apparatus appeared particularly applicable to marine boilers, where the heat of the stoke-hole was ordinarily very objectionable, and interfered seriously with the duties of the men; and he was surprised it had not been taken up by the marine authorities on that account, as well as for effecting the consumption of the smoke. Those valves that he had seen at work certainly kept quite cool, and in very complete order, and had not been injured at all by the heat.

He inquired whether any difficulty had been found in keeping the regulating cylinder in order, and how often it required replenishing with water?

Mr. PRIDEAUX replied that the cylinders were found to continue working with the same regularity as at first, and the original india-rubber pistons were still at work, he believed, in every case; except in one instance where the water had been all evaporated, and the cylinder exposed to heat unnecessarily. Various materials had been previously tried for the pistons, but none were found to answer so well as the vulcanised india-rubber, which proved quite satisfactory. The cylinders were usually filled up with water once a week; and this was quickly done by unscrewing a small plug at the top of the cylinder.

The CHAIRMAN then proposed a vote of thanks to Mr. Prideaux, which was passed.

The following Paper, by Mr. James E. McConnell, of Wolverton, was then read:—

ON AN IMPROVED WROUGHT-IRON PISTON.

This Piston is constructed entirely of wrought iron, and it is forged in one piece with the piston-rod, by means of which the ordinary joint between the piston and piston-rod is avoided, and a great saving of weight is effected.

The construction is shown by the drawings in Plate 28, which represent an 18-inch piston for a locomotive engine.

Fig. 1 is a transverse section of the piston.

Fig. 2, a side view of the cover, detached from the piston.

Fig. 3, a sectional plan, showing the interior.

The body of the piston AA, is a circular disc of wrought-iron, which is forged under the steam-hammer, with a portion of the piston-rod B, formed upon it, about 9 inches long, to which the piston-rod is afterwards welded. The circular ring CC, is also raised upon the disc in the forging, thus completing the body of the piston in one solid piece of wrought-iron.

The wrought-iron cover DD, is screwed into the ring CC, by a single thread, cut upon the projecting rim EE, on the inner side of the cover, as shown in the detached view of the cover, Fig. 2.

The cover is dished in the centre, as well as the body of the piston, so that the two sides meet in the centre, to diminish the weight of material.

The packing consists of two plain brass rings FF, lined with a thin steel hoop G, which fit into a shallow recess on the inside of the brass rings. The four steel springs HH, are set out against the packing, by set screws fixed in the ring of the piston CC. The fifth set screw is attached to a solid block I, which is placed at the bottom of the piston, and serves to support the weight of the piston, to prevent it from fluting the cylinder.

Two holes KK, are provided in the cover for the purpose of unscrewing it, by means of a bar passed through either hole K, and bearing at the point in a series of holes LL, sunk in the opposite side of the piston. The holes KK, are closed by brass screwed plugs, which are kept from turning by a thin brass plate M, fixed by split pins, as shown in the detached plan, Fig. 4. This plate also secures the brass locking nut N, for preventing the cylinder cover from unscrewing; the thread of this nut is right-handed, whilst the main thread of the cover is left-handed.

The weight of this piston, including the piston rod, is 217 lbs. for the size shown, 18 inches diameter, which is 89 lbs. lighter than the ordinay construction of pistons of the same size, weighing

306 lbs. The weight of a 16-inch wrought-iron piston and rod is 160 lbs., being 47 lbs. lighter than the ordinary construction.

This saving of weight amounts to 178 lbs. in the pair of 18-inch pistons, and 94 lbs. in the 16-inch pistons, which is a point of considerable importance at the high speed of 600 to 800 feet per minute, at which locomotive-engine pistons are driven; the consequent reduction of momentum adding to the durability of the working parts by reducing the strain upon them, as well as diminishing the disturbing effect upon the motion of the engine.

The solid construction of this piston avoids all risk of accident from the piston working loose upon the rod, which in the ordinary construction is liable to cause the fracture of the cylinder covers, and sometimes more extensive injury.

There are upwards of 200 of these pistons now in use, and some of them have been at work for two years. The lightness of the piston, and the accuracy of adjustment maintained throughout, in consequence of the absence of joints and loose parts in the construction, allow the brass packing-rings to be worn down to a greater extent than usual, before requiring renewal. These rings, of which specimens are exhibited to the meeting, have been worn down to $\frac{1}{8}$th inch from the original thickness, $\frac{3}{4}$ths inch, and lasted twelve months in constant work.

Mr. McConnell exhibited one of the pistons, 18 inches diameter, and showed the process of taking off the cover, and screwing it on again; also specimens of brass packing rings that had been worn down.

The Chairman remarked that there was great ingenuity and compactness in the construction of the piston, and the saving in the moving weight was very considerable, and was a point of importance, as well as the avoidance of a joint between the piston and piston-rod.

Mr. McConnell said the object had been to obtain a piston constructed entirely of the toughest and strongest material, wrought iron, as light as possible, and in as few parts as possible; the piston and rod indeed consisted of only two separate parts besides the

packing rings and springs; the cylinder was also shortened and made lighter by the piston being thinner. The greater accuracy of adjustment allowed the packing-rings to be worn down thinner than usual; those shown had been worn down to $\frac{1}{8}$th inch from $\frac{3}{4}$ths inch thickness, in about 9 months' work.

Mr. CHELLINGWORTH observed that one of the rings had been worn somewhat unequally, being nearly $\frac{1}{8}$th inch difference in thickness at the two ends.

Mr. MCCONNELL said the variation had probably been caused by a little difference in the pressure of two adjoining springs, arising from their not being adjusted quite equally; the rings had generally been found to wear down very uniformly.

The CHAIRMAN inquired whether any difference had been found in the amount of wearing the cylinders oval?

Mr. MCCONNELL said the difference had not been noted, but there would be a less effect in disturbing the form of the cylinder, from the piston being one third lighter than ordinary pistons, as the wear was caused only by the weight lying on one side.

The CHAIRMAN asked whether any disadvantage had been found from rusting of the iron in the interior, the piston being all made of wrought iron, and whether it had been tried in any stationary engines?

Mr. MCCONNELL replied that the joint of the cover where it was screwed in, fitted so well that water could not get in, and the water being prevented from entering the piston, preserved the interior from rusting. The piston had only been tried at present in locomotive engines, and the construction was most applicable to small quick-moving pistons.

The CHAIRMAN proposed a vote of thanks to Mr. McConnell, which was passed.

The following Paper, by Mr. Henry Wright, of Birmingham, was then read:—

DESCRIPTION OF AN IMPROVED STEAM-ENGINE BOILER.

The boiler described in the present paper (the invention of Mr. W. B. Johnson, of Manchester), has been at work successfully for more than twelve months at the Author's Works, near Birmingham; and the present description has been laid before the Institution, as the boiler appears to possess some practical advantages in efficiency and economy.

It is one of the tubular construction of boilers, and has an improvement in the arrangement, designed for the purpose of removing some objections that have been experienced in tubular boilers, and increasing the economy both of working and construction.

The boiler is shown in Plates 29 and 30, in which Fig. 1 represents an end elevation; Fig. 2, a transverse section; Fig. 3, a longitudinal section; and Fig. 4, a plan of the two boilers combined. The products of combustion from each furnace, after passing over the furnace-bridges BB, meet and mix together in the chamber D, attached to the back of the boiler; and when the furnaces are alternately supplied with a proper amount of the fuel, combustion is rendered sufficiently perfect to prevent the appearance of smoke from the chimney.

The motion given to the vapour in coming from each furnace, causes it to mix thoroughly together, after which it passes into the tubes EE, forming the heating surface of the boilers. The products of combustion are collected from the tubes into the smoke-box F, and conducted from thence by the flue G, to the chimney. The smoke-box is fitted with a damper to regulate the draught through the tubes. Two furnaces and return tubes, giving similar results, are sometimes placed in one shell or boiler casing, but the arrangement represented in the engravings is recommended, as making a simple and strong boiler; for it must be apparent, that if the two furnaces and two sets of tubes contained in the two shells were placed in one, it must be considerably larger in diameter, and to that extent become unfit for the purpose of producing steam of high pressure. Many steam-boilers have been constructed similar to this, and the result has been strongly in favour of tubular heating surface.

The boiler represented in Figs. 1 to 4, is 30 horse-power nominal.

Another arrangement of the boiler is shown in Plates 30 and 31, in which Fig. 5 shows an end elevation; Fig. 6, a transverse section; Fig. 7, a longitudinal section; and Fig. 8, a plan.

The furnaces AA, are placed inside the shell of the boiler; they are entirely surrounded with the water in the boiler, and are cylindrical in transverse section. The furnaces are placed opposite to one another longitudinally, and are supplied with fuel at each end of the boiler. The products of combustion from each furnace, after passing over the furnace bridges BB, mix together in the chamber G. When the furnaces contain a proper amount of fuel, and are alternately supplied, the consumption of the smoke is practically complete. From boilers of 30 horse-power and upwards, the amount of smoke produced is not more than appears at the top of an ordinary house chimney. The products of combustion, after mixing in the chamber, are conveyed through the tubes DD, into the smoke-boxes EE, and from thence into the flue FF, communicating with the chimney. Each smoke-box is provided with a damper G, by which each set of tubes can be regulated in the amount of heat they receive from the chamber.

The boiler shown in Figs. 5 to 8, is of 30 horse-power nominal. Two boilers of this construction are now employed at Messrs. Whitworth's works in Manchester, working very satisfactorily, and several others varying in power from 20 to 80 horse-power nominal, have been at work successfully for some time.

Stationary steam boilers with tubular heating surfaces possess many advantages, and experience has brought them into notice more fully than any mere theoretical consideration could have done; at the same time it has brought to light difficulties that were not at first anticipated.

The advantages of tubular boilers are found to be—

1st, Economy in fuel, requiring from 25 to 30 per cent. less fuel for the same amount of duty than the two-flued boiler.

2nd, They are fixed and set to work with less cost and labour, not requiring any brick flues to surround them.

3rd, They can be examined and repaired with ease and facility, having no brick flues to be removed before they can be inspected.

4th, They are not injured by using dirty water, as the sediment falls to the bottom of the boiler, where there is no heat transmitted through the plates, consequently it does not adhere to the boiler shell, but lies loose, which is not the case with boilers having brick flues round them.

5th, The heating surface is renewed with less labour and cost than the heating surface of any other kind of boiler.

6th, The shell of the boiler is more durable, not being acted upon by the fire nor by the brick-work, as are boilers with brick flues round them. Brick-work round boilers is found to do more injury than anything else; in most cases when boilers are done and worn out, it has been the brick-work alone that has caused it, in connection with a few leakages, or an accumulation of moisture, of which nothing is known until the injury is done.

7th, They will sustain a greater pressure than other boilers, the same power being obtained in less space or diameter of shell.

8th, They occupy much less space than other boilers, and are more easily moved from one place to another.

9th, They require less time to do the same amount of duty; for instance, steam is raised in about one-fourth the time that other kinds of boilers require; also, in checking the production of steam, less trouble and time is expended; by shutting the dampers and opening the fire-doors, it is stopped immediately; but with boilers set in brick-work, it requires a considerable time to heat and cool the brick-work with which they are surrounded, which must be done before the boilers can either be put into or out of action.

Some difficulties have arisen in carrying into practical use this mode of obtaining the heating surface of steam-boilers, still none have yet appeared that may not reasonably be expected to be overcome.

Some of the difficulties are found to be—

1st, In firmly attaching the tubes to the tube-plates; this arises

in many instances from defect in the materials or workmanship; but it still is a fact that with all the care that has been given in making, the tubes sometimes become leaky and loose in the attachment to the tube-plates, before the tubes are properly worn out in other parts. The most effectual remedy for this appears to be, to make the end of the tubes fixed to the tube-plates much thicker than in the body part, by which the tube ends will be able to maintain that amount of expansive force which is absolutely necessary to form a firm connection between the tubes and tube-plates.

2nd, It has been found in many cases extremely difficult to keep the interior surfaces of the tubes free from sooty deposits; this often arises from the tubes not being of proportionate diameter to their length; also, from the imperfect combustion of the gases from the furnaces, producing in such instances a great amount of smoke. This difficulty is effectually removed by making the tubes of proper proportions, and consuming the smoke before it enters into them. Some boilers made upon the arrangement shown in the engravings, have tubes only $2\frac{1}{4}$ inch diameter, which are found to work well, with cleaning out once in three or four months during constant work.

3rd, Another difficulty in some arrangements of tubular heating surface, appears to be in keeping the exterior surfaces of the tubes clean. This difficulty is not found to exist when the tubes are placed in vertical rows, leaving a clear vertical space between them from the top to the bottom row. But when the tubes are arranged in diagonal rows, where each tube comes just under the spaces of the row above, this difficulty becomes of serious import, particularly where the water contains materials liable to deposit, the scale from one row of tubes falling upon the tubes below, and thus the spaces between the tubes are liable to become choked up, and the tubes are rendered useless as heating surface.

Tubular heating surface in steam boilers has the advantage, that the heat is brought into contact with no other surfaces but those that are surrounded by the water intended to be converted into steam. The heat is also divided into a considerable number of small streams

or currents. Each stream or current of heat is exposed to a considerably larger amount of surface in proportion to its quantity than can possibly be obtained by any other mode; and a large amount of heating surface can be obtained without causing the heat to travel an objectionable distance from the place of its production. The desirableness of heat acting upon surfaces only in contact with the water to be converted into steam is evident; and in no other construction of heating surface is this so fully obtained as in the tubular.

The heat being divided into a number of small streams according to the number of tubes, facilitates its transfer to the water with which each stream is surrounded; the heat is, in fact, sifted through the water by passing through the tubes.

In the comparison of a tube 3 inches diameter inside, and flue of 24 inches diameter inside, the capacities of the tube and flue for the heating vapour being in proportion to their cross sectional areas, will be as 7 to 452 square inches; therefore, the 24 inch flue will carry 64 times as much of the vapour containing the heat as the 3 inch tube. The surfaces, or circumference of the tube and flue, are $9\frac{1}{2}$ inches, and $75\frac{1}{2}$ inches respectively, or the surface of the flue is eight times that of the tube; consequently the tubular heating surface in this example has an advantage of 7 to 1 over the flue heating surface, supposing that both are supplied with an amount of heat in proportion to their respective cross sectional areas.

Tubular heating surface is obtainable within a much less distance from the furnace than any other kind, an advantage of no small importance, when it is considered how much cleaner the surface thus placed is kept by its proximity to the furnace; and the heating surface is thus made more effective. The further the heating surface is from the furnace the greater is the amount of deposit upon it; as is well known from experience in the use of boilers of the ordinary construction.

An important principle, applying to all kinds of heating surface, appears to a great extent to have been overlooked in the first constructed tubular boilers, namely, that the vapour containing the heat, should pass slowly over the heating surface, and also, that the vapour should pass evenly over the heating surface.

That the vapour containing the heat to be transferred may be carried too quickly over the heating surface, may be illustrated by passing the finger through the flame. If it is passed through the flame quickly, say at a speed of 10 feet per second, scarcely any perceptible heat will be transferred from the flame to the finger, and the transfer of heat increases as the speed is reduced.

Supposing a steam-boiler required 100 square feet of heating surface on the tubular construction, if long tubes were used, this surface would be obtained by taking eight tubes 16 feet long, and 3 inches internal diameter; but with short tubes, it would be obtained by using sixteen tubes 8 feet long, of the same diameter.

The vapour containing the heat to be transferred, in passing over the heating surface formed by the long tubes, will travel at double the velocity that it will in passing over the surface formed by the short tubes; or the vapour will pass through the long tubes in the same period of time as through the short ones, and consequently travel at double speed.

The slow passage of the heated vapour over the heating surface appears still further important, when it is considered that atoms of heat in being transferred from the vapour to the heating surface, move in directions at right angles with the current of the vapour. The vapour, when travelling with rapidity, has a tendency to carry the heat along with it; and it might, perhaps, be possible to convey vapour containing a considerable amount of heat, so rapidly over a suface, as that no perceptible heat should be transferred.

Considerable difficulty in many steam-boilers having tubular heating surface, has arisen in evenly distributing the heat; one part of the heating surface having more heat transferred to it than another part, some of the tubes receive a larger amount of vapour from the furnace than others. This is objectionable, in as much as the duty of the steam-boiler is diminished thereby; a part of the heating surface not being in proper action, must of necessity reduce the amount of duty performed by the boiler.

The most successful mode of combating the difficulties is, so to arrange the position of the furnaces relative to the tubes, and of the draft from the tubes to the chimney, as that the tubes shall be

all equally disposed to receive the vapour as it comes from the furnaces.

The boilers described above, that are in use at the Author's Works, have been in constant work for a year, with very satisfactory results. No failure has occurred of the tubes, or any other part, and the tubes are not found to choke up, the smoke being very completely burnt, the deposit of soot in the tubes is thereby prevented, and they have not required cleaning out since first starting work. The tubes are wrought-iron, 2 inches diameter, and 8 feet long.

The fuel consumed is sawdust and rubbish of the carpenters' shops, with a small proportion of coal-slack, and the boiler is found to keep up the steam well, of 50 lbs. per inch. The construction of the boilers, and the arrangement of the two in combination, is found very serviceable in economy of fuel, allowing very inferior quality to be used, and the consumption of the smoke is accomplished very completely, scarcely any trace of smoke being visible, except for a short time when lighting the fire, or getting up a low fire.

The Chairman remarked that so many multitubular boilers had been invented, all varieties of the same principle, that it was difficult to judge between them; the present one was compact in space and arrangement, and seemed to have advantages in that respect as well as in simplicty of construction. It was also in the best form for resisting pressure, the longitudinal tubes and main flue acting as direct stays to the flat ends of the boiler; the longitudinal stay rods in the upper part were more generally replaced by oblique gusset pieces in the present construction of boilers, staying the flat ends to the cylindrical portion, which he thought was the preferable plan.

Mr. Wright said that another practical advantage in such boilers as the one described, was the small space that is occupied by a boiler for a large engine, which could be fitted complete in the maker's shop, and only requires laying down in its place on two or three sleeper walls, with a connection to the chimney flue; no brick-work for setting the

boiler is required, only a fire-brick lining for the smoke-box. This was a great advantage in the convenience and expedition of fixing boilers in works, where space and time are very valuable.

The CHAIRMAN inquired whether the consumption of smoke was accomplished by alternate firing of the two boilers, keeping one of them always with a bright fire? In double boilers it was generally practicable to effect the consumption of the smoke pretty completely, if sufficient care were used in firing alternately, though doubtless not so efficiently as by some special contrivance, such as Prideaux's Valve, which had been described.

Mr. WRIGHT said that alternate firing was the plan adopted for preventing smoke, and the two boilers combined gave the best effect, but they also worked very well singly. The tubes had not required cleaning out in his own boilers during the twelve months' constant work since they were put up, as no deposit of soot had taken place in them; but they could be readily cleaned if required, by taking off the front smoke-box, which was merely a plate held by a few bolts, and covering the opening to the underground flue.

Mr. PRIDEAUX asked whether the consumption of smoke did not much arise from sawdust and wood rubbish being mainly used as fuel, which would give much less smoke than bituminous coal? The marine tubular boilers were similar in construction except that the return tubes were placed above the fire flues, which communicated together by a chamber at the back before reaching the tubes; but these boilers were very deficient in consumption of the smoke with bituminous coal.

Mr. WRIGHT said there was more smoke when coal was used, but it was still found to be very small when firing alternately with Staffordshire coal alone, and scarcely more smoke than from an ordinary house fire.

Mr. MCCONNELL inquired whether Mr. Johnson had made any experiment to determine the evaporative economy of the boiler as compared with other kinds of boilers; and what was the proportion adopted between the tube and flue surface?

Mr. JOHNSON replied that the proportion of the tube surface was about 20 to 1. In reference to the economy of fuel, he had made some trials with the boiler at Manchester, and found the evaporation to be 9 lbs. of water per lb. of fuel, with Lancashire coal.

Mr. McConnell thought there must be heat lost in the first smoke-box or combustion chamber, which might be made use of. The arrangement of the boiler, he thought, was on the correct principle, but would suggest that instead of lining it with fire-brick, this chamber should be surrounded with a water-space, either forming part of the boiler, or for heating the feed water, as there must be much heat impinging on that surface, and lost by radiation outside, which might be usefully absorbed.

Mr. Johnson said he had made the first of these boilers in that manner, with a water casing, in which the feed water was heated; but after about eight months' working, he found it had got so much choked up with deposit from the water, that the use of it was abandoned; since then he had not found any appreciable loss in economy of fuel, and had therefore adopted the fire-brick casing, as it had an advantage in simplicity of construction.

Mr. McConnell inquired whether the iron plate was not found to burn away with the fire-brick alone to protect it, as it was exposed to great heat, and wrought iron was liable to oxidate rapidly under those circumstances?

Mr. Chellingworth observed that he had seen several of the boilers, and they worked very well; but there was a great heat thrown off by radiation from the back of them; in some cases, so much as to make it inconvenient to stand near the end of the boilers.

Mr. Johnson said he had not found the plate get so much heated as to be objectionable when properly lined with fire-brick, and thought the lining must have been out of repair for such to be the case; if there were cracked joints in the fire-brick lining a good deal of heat would get through to the iron plate.

Mr. Fernie remarked that he had fixed five boilers of a similar construction, only single instead of double, and he had found them work very satisfactorily; being single they were not so well adapted to burn the smoke as when arranged in pairs; he found however with ordinary care there was very little smoke from them. These boilers were constructed without any flattened surfaces, which he considered an advantage. He thought there would be an unnecessary loss of heat with the use of a fire-brick lining, and intended to heat the water of a

tank in one case of a boiler fixed at a brewery, by applying a water-casing to the back chamber, connected with the tank by two pipes for the circulation of the water.

Mr. McConnell said he quite agreed with the opinion in favour of short tubes that had been expressed in the paper: his own experience had led him to the same conclusion, that short tubes, not longer than 7 or 8 feet, were the best; the loss from friction in long tubes must be very considerable, as well as the loss in the communication of heat from the greater velocity of passage of the absorbing surface. The boiler described was certainly advantageous in portability, and in the simplicity and strength of construction, being well stayed by the longitudinal tubes and stays, all forming a direct support in the line of the strain.

Mr. Johnson observed that he had made the first boiler with tubes 8 feet long, and afterwards found by reducing their length to 5 feet, and increasing their number to give the same total surface, a saving of 10 per cent. was effected; he had always found a saving of fuel to be effected by employing short tubes, the speed of passage of the vapour being so much reduced, more time was allowed for extracting the heat.

The Chairman said he believed the progress of improvement in boilers was tending generally in the same direction, in the great variety of constructions that had been recently proposed—namely, the diffusion of the heat over the largest surface, and at the slowest speed, as far as was compatible with practical limits. He had constructed many boilers, similar in general principle to the one described, and they were becoming very extensively used in the manufacturing districts; boilers that were not set in brick-work were preferred there on account of the small space they occupied, and the convenience and expedition with which they could be fixed and examined at any time for repairs. In these boilers it was found best for the tubes generally not to exceed 8 feet length, as that length of tube cooled down the current sufficiently, leaving not more heat than was desirable for the draught; the application of short tubes had also been extended to locomotives in Mr. McConnell's boiler. The subject of maturing the best form for steam boilers was one of great importance, and he hoped the members would attend to working out the subject by combining their practical experience.

The CHAIRMAN proposed a vote of thanks to Mr. Wright and Mr. Johnson, which was passed.

Mr. WRIGHT offered to show the boilers at his works, to any Members who might wish to examine them.

The following Paper, by Mr. James Kitson, of Leeds, was then read :—

DESCRIPTION OF AN IMPROVED FRICTION HAMMER.

The hammer described in the present paper has been in use for some time at the Author's works, in Leeds, where it was originally constructed as a simple and inexpensive hammer, for the heavier smiths' work; and the present description has been prepared only in compliance with a request to communicate to the Institution the particulars of this hammer, as possessing some practical advantages of efficiency and simplicity.

An elevation of the hammer is shown in Fig. 1, Plate 32, and a plan in Fig. 2, Plate 33.

The hammer block A, weighing 5 cwt., is guided by grooves in the same, BB, and is lifted by the flat wrought-iron friction bar CC, $5\frac{1}{2}$ inches wide, and $\frac{5}{8}$ inch thick, fixed into it by a T head, with two cotters, SS.

The friction bar C, is raised by two rollers D and E, carried on the cross frame at top, one of which D, runs loose on its axle, and the other, E, is fixed on a shaft which is driven continuously by the pulley F, and carries a fly-wheel GG, at each end, to give momentum for lifting the hammer.

The axle of the roller D, is carried by a bent lever H, which works on a fixed centre I, below the roller, and has a chain connected to the outer end, passing over a pulley T, and attached to the weight K. This weight presses the tightening roller D, towards the driving roller E, and grips the friction bar C, between them, causing the hammer to be drawn up rapidly; the hammer being prevented from being lifted too high by a timber stop at the top of the frame.

A handle L, is connected by a rod to the extreme end of the lever H, and by pressing down this handle, the tightening roller D, is drawn back slightly, releasing the friction bar C, and allowing the hammer to fall. On releasing the handle L, from the pressure, the hammer is again lifted by the bar being gripped between the rollers, and it is again let fall from any height desired by pressing down the handle.

The man holding the handle has thus complete control over the hammer, by simply pressing down the handle, or letting it rise again; and he can readily regulate the rapidity, or length of the stroke, as required. The present hammer makes from 25 to 30 strokes per minute, when lifted to the full height, 5 feet; about 40 per minute with a stroke of 2 feet, and 84 per minute with 14 inches length of stroke. The driving pulley makes 132 revolutions per minute, when the hammer is at work.

The second handle M, works a friction clip or break N, serving to check the hammer, and hold it fast in any position. This break N, is fixed at the end of a second bent lever O, working on a centre below, and lifted by a chain U, and a second weight P, working by the side of the other weight, inside one of the hollow columns of the framing. This weight presses the break towards the tightening roller D, the lifting bar being gripped between them by the opposing pressure of the two weights, holding up the hammer in any position that it may be in.

The break handle M, is held down continuously whilst the hammer is working, the man holding this in one hand, and the lifting handle L, in the other hand; by means of which the working of the hammer is managed with great expedition and accuracy, and it can be instantly stopped and held fast whenever required, by merely letting go the break-handle.

The grip of the lifting rollers, and of the break, is always the same, being produced by the pressure of the two weights, and consequently always properly adjusted, not being dependent on the pressure of the man's hand, which is only employed to release the pressure of the weights.

The frame that carries the bearings of the lifting rollers and break, is mounted upon four india-rubber springs RR, fixed upon the main

cross frame, for the purpose of relieving the friction bar from the shock of suddenly putting the hammer into full motion, when the lifting rollers lay hold of the bar; the india-rubber springs are compressed at the first moment, allowing the lifting rollers to drop a little, whilst the hammer is getting into motion.

The bottom T end of the friction-bar is bedded upon several thicknesses of wood, 12 inches thick in all, fixed in the hammer block, the elasticity of which relieves the lifting-bar from the end concussions, when each blow of the hammer is struck.

When this hammer was first constructed, the friction-bar, which was rather smaller, 4 inches by $\frac{3}{8}$ths inch, was fixed in the hammer with a single 4-inch piece of wood below it, and the india-rubber springs were not adopted; and it was found that the cotters, SS, broke very frequently, about twice a week. India-rubber $\frac{3}{8}$ths inch thick was then put in between the cotters and T head of the bar, with a better result; and the india-rubber springs were afterwards introduced, with the wood packing below the T head of the bar; this arrangement has been found to work very successfully, and it has been in regular work for the last nine months without accident or repair.

The only wear that is found to take place in the machine, is in the friction-bar, near where it is first caught by the lifting rollers, for a length of about 14 inches; the wear being at the rate of nearly $\frac{1}{8}$th inch thickness per week, when in constant work. This repair costs very little time and expense, requiring only smiths' work; but in the case of making another similar hammer, it would be preferred to make the bar 7 inches wide instead of $5\frac{1}{2}$ inches, to diminish the wear.

The CHAIRMAN said, he regretted that Mr. Kitson had been unexpectedly prevented from being present at the meeting; he thought the hammer that had been described, was an ingenious and efficient arrangement, and would prove useful and economical in many smiths' shops. The same principle might probably be advantageously applied to many of the stamping processes, in brass and iron manufactures, such as those of the Birmingham district, in place of the slower and more expensive processes of hand labour, at present in use.

Mr. McConnell remarked, that he had seen the hammer at work, in Mr. Kitson's works, and was much pleased with its action. It was a very efficient machine, well arranged for the purpose, giving a very complete command over the action of the hammer, with a simple and inexpensive construction. He thought that kind of hammer was very applicable, where a steam hammer would be too expensive; and he was strongly of opinion, that power hammers would soon become much more generally used, in all works, in place of hand labour, as a great part of the ordinary smiths' hammer-work might be done more efficiently and economically by power.

Mr. Middleton said he remembered seeing a hammer working on the same principle, at Messrs. Jones and Potts' engine works, which was found very useful and efficient; the friction bar was made about 5 or 6 inches wide, and $\frac{3}{4}$ inch thick, and it was not found to wear away objectionably. He quite agreed with the suggestion, that a power hammer on the same principle, might be advantageously employed in many cases of stamping metals, and he had some two years since proposed to make one on the plan, and offer it to Messrs. Elkington, or some other manufacturers for experiment, but it had not been completed.

Mr. Sampson Lloyd said, he had had a friction hammer on a similar principle in use for some years, in his works at Wednesbury; it worked well, and was found a useful tool; they had not found any great wear of the friction bar take place, and the same bar had been working for a year, he believed, without requiring repair.

The Chairman remarked that the hammer described in this paper seemed to have a defect in the rapid wear that took place in the lifting bar, and he thought this might be avoided by adopting some different material: he inquired what was the difference in the construction of Mr. Lloyd's hammer?

Mr. Sampson Lloyd replied that the lifting rollers were faced with wood, which prevented the wear of the friction bar; the rollers were worn away instead of the bar, but the wear of the rollers was not important, the wood lasted for nearly a year, he believed, without renewal.

The Chairman inquired what was the direction of the wood on the lifting rollers; he thought that wood fitted into the roller endways of

the grain, like cogs in a wheel, would be the most durable and effective in gripping the bar.

Mr. Samuel Lloyd, Jun., said, the wood was fitted into a groove on the circumference of the iron roller, (which was of large diameter,) in segments flatways of the grain, but it might probably be still better endways; the lifting bar was $1\frac{1}{4}$ inch thick, and $4\frac{1}{2}$ inches wide; it had been in use for the last two years, without material wear, but it had not been in constant work during the time. The hammer weighed 5 cwt., and the frame was continued down parallel in the centre, so as to guide the hammer more firmly during its fall, which he considered an advantage in the durability of the machine; also, they had not found any want of india-rubber springs in the action of the hammer, the wood rollers appeared to yield sufficiently to prevent any injurious shock on lifting the hammer.

Mr. Fernie said he had seen a similar hammer in use some ten years since at Messrs. Forrester's works in Liverpool, which worked very well; with the exception of the india-rubber springs, the machines were nearly the same. The hammer and lifting bar were formed of one peice; the lifting bar, he thought, was rather wider for the weight of hammer than the one before the meeting, and he thought with that addition, and the wood rollers that had been named, it would be a most useful tool.

Mr. McConnell remarked that the advantage of applying power in place of hand labour, was being experienced more and more in all manufactories, and the application was extending more rapidly than it had done, as more effective and expeditious, as well as more economical; at the Wolverton works they had greatly increased the number of power hammers, as well as other machines, with a marked advantage in economy, and facility for executing the work.

Mr. Johnson observed that another instance of the same principle was Ryder's forging machine, which was found very convenient and advantageous, and was now used to a large extent in Manchester and other places, taking the place of hand work, and making an important saving in expense and time.

The Chairman said he had lately seen a number of those machines in the Government factory, at Woolwich, where it was intended to have

all the hard labour of forging done by machinery, and a long range of these machines were being erected down one side of a shop, with the fires adjoining, and merely requiring to be attended by one man each. In those machines the motion was given by an eccentric, and the strokes were very rapid, being suitable for the smaller hand forging;—the friction hammer that had been described in the paper read, was adapted for the heavier hand-work, for which it appeared well suited, and also probably applicable with advantage to other manufacturing processes.

He considered it was an important advantage that the Institution afforded the opportunity of bringing forward such practical subjects, and eliciting valuable information in their discussion from the experience of the Members.

He proposed a vote of thanks to Mr. Kitson, which was passed.

The CHAIRMAN then said that he had the pleasure of presenting to the Library of the Institution a set of the Memoirs of the Manchester Literary and Philosophical Society, from the commencement in 1781; and he hoped that all the Members would aid in extending the Library, by donations of books, or drawings and models, of interest to the Institution.

He remarked that the next meeting of the Institution would be the Annual Meeting; and he hoped that on that occasion and the usual Annual Dinner after the Meeting, there would be a numerous gathering of the Members and their friends; and observed that it was contemplated to make arrangements for inviting several distinguished scientific men to meet the Members on the occasion.

The Meeting then terminated

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